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STUDIES ON THE HABITS OF SPIDERS, PARTICULARLY THOSE OF THE MATING PERIOD.

BY THOMAS H. MONTGOMERY, JR.,[1] PH.D.

It is remarkable how little the habits of spiders have been pursued, in consideration of the fact of their many peculiarities. Their webs and the making of them have received the most attention, and next to that their architecture of nests and burrows. A great literature has grown up about the subject of the "threads of the Virgin," as to the use of spiders in medicine, and as to their supposed venomous bites. On the subject of generation, where the spiders are especially removed from other animals, for the most part only scattered and brief observations are to be found, and these mainly among the older observers. Menge, who saw and described more of the mating habits than any other naturalist before or since, took the pains to watch each of his specimens alive in a bottle before killing it, and this was the simple secret of his success. Most of the other recorded facts of mating, except the notable ones of de Lignac, Bertkau and the Peckhams, were gleaned from chance observation in the field, which must be necessarily less full and precise. Let the arachnologist watch his spiders in the life before he kills them to describe their carcasses, and the facts of structure will have a richer and more inspiring influence.

And of further interest is the consideration that spiders were first classified according to a certain set of habits, namely, the architecture of their webs, and some of the groups thus early defined are still rectified by morphological characters. In them is to be found a good opportunity for examining the conservatism of habit, and for testing how much reliance in taxonomy may be placed upon similarities of habit—similarities that may persist through great changes of structure.

The present study concerns mainly the processes of courtship and copulation, the remarkable filling of the palpi with sperm (for which the term "sperm-induction" is here introduced), the process of cocoon-making, and the maternal care for the young. Other observations have also been included on moult, and in some cases on feeding habits.

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[1] Contribution from the Zoological Laboratory of the University of Pennsylvania.

The genera studied and the families in which they are grouped are the following: Lycosidæ (*Lycosa, Pardosa, Pirata, Ocyale*), Agalenidæ (*Tegenaria, Agalena*), Dictynidæ (*Dictyna*), Theridiidæ (*Theridium, Teutana, Steatoda, Linyphia*), Pholcidæ (*Pholcus*), Epeiridæ (*Epeira, Acrosoma*), Thomisidæ (*Xysticus*), Philodromidæ (*Philodromus*) and Drassidæ (*Prosthesima, Thargalia, Drassus*). The Attidæ were purposely omitted, since good work has been done upon them by the Peckhams.

The method employed was to keep the smallest species in glass test-tubes, the others in glass boxes of various sizes. A considerable variety of the latter were made by using microscope slides and old photographic plates from which the films had been removed. Strong gummed linen was used for holding the parts together. A very convenient glass cage for observing the mating of small Lycosids is to take a photographic plate 11 x 8 cm. as a base, three microscope slides (each measuring 7.5 x 2.5 cm. or 7.5 x 4 cm.) as the walls, arranged together in a triangle with their narrow diameter vertical to the base, and the ends of two of the slides with just sufficient aperture between them to allow the placing of another slide as a movable partition; and finally two slides, each 7.5 x 4 cm., as covers. Where the edges of any two of the walls meet at an angle a strip of gummed linen is pasted on, also at the angle of each wall with the floor; and by gummed linen strips the glass covers are hinged to the upper edge of one of the walls. Thus one can make a tight and strong cage, with two compartments separated by a glass partition, and each compartment with its own hinged cover. Other cages were made rectangular without movable partitions; and for the larger species, and for those that make webs, large cages were made of photographic plates entirely. Such cages are readily and cheaply made, and more than a hundred of various sizes and forms were employed. Their advantages are obvious. The whole is of glass, the linen strips which hold them together can be made narrow and short and placed so as not to interfere with any observation. The floor being also of glass, one has simply to hold the cage over a mirror to see the spiders from underneath, and its surface retains in drop-form water introduced for drinking purposes. When the floor has become soiled with excrement or remains of food, the gummed linen that holds it to the walls may be torn off, the floor washed, then returned and gummed into position again. It is of great advantage to have the floor removable in the case of species which build a web in the upper part of the cage, for then it may be removed and cleaned without injury to the web. For species that cannot easily climb the smooth glass walls, such as the heavier Epeirids, threads may be tied upon these walls to give them a foothold. To observe burrowing habits one should put earth in the cages.

Small spiders may be used as food when insects are not obtainable, house flies at other times. All ground spiders need water frequently, and the species of *Pirata* quickly die from thirst. Attempts to feed the spiders with beef extract were unsuccessful.

It is by no means sufficient, however, to simply place the spiders in their glass cages. Great patience in expectant watching is demanded, and no results can be gained unless long continuous periods can be given to this watching. To observe the mating, the spiders should be collected in their natural mating season, and mature males introduced to females which have just become mature; and in the case of the Lycosidæ the collecting should commence in the early spring. Partition cages are most useful for the spiders which do not spin webs, as they obviate any handling; in the web-making species the male should be gently dropped from a test-tube upon the web of the female; in no case should the spiders be handled with forceps. Freshly caught specimens generally give the best results. The considerable number of deaths which resulted during the month of September were mainly on account of starvation, due to my absence at that time.

This contribution is divided into three parts: Observations, General Considerations, and a list of the literature bearing upon the subjects of courtship, mating, parthenogenesis, cocooning, sexual selection, and care of eggs and young. The literature list it has been my aim to make as complete as possible.

The species of *Dictyna, Teutana, Steatoda, Linyphia, Xysticus, Drassus* and *Philodromus,* Mr. Nathan Banks, Assistant in the Division of Entomology, U. S. Department of Agriculture, has kindly identified for me, and it gives me pleasure to express my thanks here for this service.

Finally, I would dedicate the work to the one who cheered long vigils of observation with her sympathy.

Lycosa stonei Montg. Pl. V, fig. 10.

This small species is found abundantly in local woods in the spring and early portion of the summer, running upon the dead leaves on the ground. Later in the summer it becomes rarer, the females then hiding themselves under stones, and the males disappearing. The general coloration of the female is an admirable adaptation to the color of dead leaves; the male is smaller, mainly deep black in color, and the tibiæ of his first pair of legs are covered with vertically implanted bristles, not so conspicuously, however, as the male of *L. ocreata pulchra.* It is very readily kept in captivity, when supplied with sufficient water.

Individuals observed, males: No. 34, captured May 4, immature, killed May 10; No. 37, captured May 4, moult May 24, killed the same day by a ♀; No. 151, captured May 26, killed by ♀, June 16; No. 164, captured May 31, killed by ♀ on the same day; No. 236, captured June 22, killed by parasite July 21; No. 238, captured June 22, died July 8; No. 240, captured June 22, died June 27; No. 284, captured July 2, died July 7.

Individuals observed, females: No. 36, captured May 4, moult May 7, died in November; No. 51, captured May 6, killed May 11(then immature); No. 165, captured May 31, still living; No. 184, captured June 10, died October 4; No. 227, captured June 27, still living; No. 228, captured June 22, escaped July 20; No. 229, captured June 22, escaped August 11; No. 230, captured June 22, escaped late in September; No. 231, captured June 22, died October 18; No. 237, captured June 22, killed by parasite July 3 ; No. 239, captured June 22, killed by parasite August 26; No. 241, captured June 22, moult July 19, killed by parasite about September 8; No. 244, captured June 22, moult July 3, died August 16 (then not mature); No. 285, captured July 2, killed by parasite about September 1; No. 287, captured July 2, killed by parasite about September 30; No. 324, captured July 23, still living.

Moult.—♀ No. 244 moulted in about half an hour, hanging to the wall of her cage by her spinnerets; she fell out of the old skin, which was split horizontally along its whole length backward almost to the spinnerets. ♂ No. 37 took only a few minutes to complete his moult.

Mating.—The following records were made on this process:

(1) ♀ No. 36. Several males were put in her cage before she had completed her final moult, on May 7, but there was no courtship. Then after similar results with males Nos. 34 and 37, the latter was introduced again on May 24, when she killed him. On May 27 ♂ No. 151 was introduced; courtship followed but no copulation. At 2.15 P.M. on May 28, the same male was put in and immediately started his courting motions. These consisted of the following movements: The male generally walks with his first pair of legs stretched before him, tapping the ground with them occasionally; this is evidently to feel the objects in front of him. When he had touched the female with them, he immediately recognized her sex, stood higher upon his legs, raised his first pair and flexed them backward at the femoro-tibial joint, then straightened them out in front of him again, repeating this several times, and at the same jerking his whole body backward and forward with the movement without changing the position on the ground of the other feet; there was no waving of the palpi. He left her, walked around the cage, returned and repeated the motions; they were then face to face, when she lowered her head to the ground,

flexed her legs closer to her sides and, so to speak, cowered before him. Then from in front he walked over her head, and embraced her tightly with his three anterior pairs of legs; his head was pointed toward her posterior end and just above the pedicel of her abdomen. In the copulation he would turn his cephalothorax first a little to one side of her body, then to the other, throwing both palpi over that side of hers to which he had turned. When his head was turned toward her right side, his right palpus would be stretched down along the right side of her abdomen and inserted in the epigynum; when toward her left side, the left palpus would be inserted. Thus to alternate the palpi he had each time to slightly change his position upon her, but the grip of his legs remained unchanged. Each palpus would be rubbed against her epigynum until inserted, then kept there until an invaginated swollen sac of the palpal organ had collapsed, a period not exceeding twenty seconds, when the palpus would be withdrawn and rubbed between his chelicera. The following palpal insertions were made, the abbreviations *r* and *l* being used for right and left palpus respectively, the first numbers giving the time extent, the second the number of insertions into the epigynum: r, 2.18–2.20, 3 or 4; l, 2.20–2.21, 5; r, 2.21–2.28½, 4; l, 2.28½–2.31½, 7; r, 2.31½–2.38¼, 6; l, 2.38¼–2.53½, 15; r, 2.53½–3.01, 9; l, 3.01–3.11, 7; r, 3.11–3.19, 6; l, 3.19–3.26, 5; r, 3.26–3.30, 3; l, 3.30–3.36¼, 4; r, 3.36¼–3.38, 4; l, 3.38–3.42½, 3; r, 3.42½–3.46, 3; l, 3.46–3.50½, 3; r, 3.50½–3.59, 4; l, 3.59–4.04, 3; r, 4.04–4.07, 2; l, 4.07–4.12, 2; r, 4.12–4.18½, 3; l, 4.18½–4.23½, 2; r, 4.23½–4.26, 1; l, 4.26–4.28, 1; r, 4.28–4.31, not inserted once. Then he rose and moved away and was taken from the cage; she remained motionless for several minutes afterward in the same attitude; her only movements during the copulation was to flex the side of her abdomen upward to meet the palpus applied. This copulation lasted 2 hours and 13 minutes. At 7.40 P.M. on the same day he was put in again, but she received him hostilely with upraised fore-legs. On May 29, when introduced, he courted again, but she was hostile, and this was repeated on May 31.

(2) ♀ No. 51 was immature, and was very aggressive to ♂ No. 41, whom she killed on the last occasion; he had made no courting movements. As other females of this species, when she is hostile to a male, with uplifted fore-legs she moves very slowly and stealthily toward, then makes a quick rush at the male.

(3) ♀ No. 165 killed on May 31 ♂ No. 164, after courtship. ♂ No. 151 was introduced on June 2, but though he courted at first, he soon ceased by reason of her aggressiveness. On June 3 the same male

was put in for more than an hour; he courted with interruptions, she would sometimes jump at, sometimes run from him. On June 5 the same male was introduced at 5.00 P.M. He immediately commenced his courting motions and came close to her, when she jumped at him; he turned away and walked around the cage, still courting, came back face to face with her; she lowered her outstretched fore-legs, bent her head to the ground, and he embraced her and commenced the copulation. The attitudes were as in the case of ♂ No. 151, ♀ No. 36. The copulation lasted from 5.02 until 6.17 P.M., that is 1 hour and 15 minutes; the palpi were quite regularly alternated, the right used 12 times and the left 13 times. The male then rose and left her, and was removed; the female remained in the same position until 6.24. In the early part of the copulation the palpus was kept inserted for 4–5 seconds; in the latter part, for 20 seconds.

(4) ♀ No. 184 made her cocoon on June 29, and so was pregnant when I introduced ♂ No. 151 on June 12 and 13; both times she reacted hostilely to his courtship.

(5) ♀ No. 237 was parasitized. On June 22, 23 and 26, ♂ No. 236 was introduced and courted each time, but she was hostile. In his courtship both legs of the first pair were not always moved in unison, but sometimes alternately.

(6) ♀ No. 239 was also parasitized. On June 22, 23 and 24, ♂ No. 238 was placed in her cage and he courted, but she repulsed him each time. June 26 ♂ No. 236 (just after his courtship of ♀ No. 237) courted her, but in vain, and this was the case with ♂ No. 238 on July 1.

(7) ♀ No. 241, likewise parasitized. ♂ No. 240 was introduced on several occasions, but though he courted there was no response.

(8) ♀ No. 244 was not mature, and males Nos. 267, 284 and 326 when introduced did not court.

Thus there is quite a distinct courtship by the male of the mature female, even when she is pregnant. The courting motions are modifications of the cautious feeling motions; the stretching out of the first pair of legs enables the male to feel and so to guard himself. Even in his ardor, then, the instinct of caution toward a stronger individual is not lost. When the female stands high upon her legs and stretches out her fore-legs, it is the same attitude of guard but with offensive intent; a frightened female, when attacked by a stronger individual, does not make use of this attitude, but slinks away. The female shows her willingness to the male by depressing these fore-legs. The bristly tibiæ of the male are shown off by the courting movements of the male;

but other Lycosids without such armature make similar movements. That sight pays a considerable part in the mating of this, as of other Lycosids, is shown by the actions at a distance. But apparently the first recognition of sex is by touch.

Sperm-induction.—♂ No. 151 concluded his copulation with ♀ No. 165 at 6.17 P.M., June 5. At 7 P.M. of the same day he cleaned himself, then went to one corner of the cage and commenced to brush his spinnerets over the floor. He formed a roughly-made small sheet of web of triangular outline, one side of it on the floor, one on the wall of the cage, and the third (the longest) free in the air from the wall to the floor. With his chelicera he then tore away some of the silk on this free edge, making it smoother there, doing so from 7.10 to 7.25. Next he placed himself above the sheet as follows: The ventral surface of his cephalothorax upon the upper free edge of the sheeting so that his palpi hung down over this edge, his abdomen slightly elevated above and parallel to the sheet, the legs of his right side against the vertical glass wall, those of his left upon the floor. At 7.28 a small yellowish drop of sperm, its diameter not greater than that of one of his metatarsi, fell from his genital aperture on the superor surface of the sheet at about its middle point. He then reached his palpi downward and backward, below the sheet, and applied the concave portion of the palpal organ of each against that part of the sheet which carried the drop of sperm. Each palpus was thus rubbed against the lower surface of this drop several times, then withdrawn and slowly shaken in the air, while the other was similarly applied to the drop. This continued until 7.35, by which time all of the sperm had been taken into the palpal organs. He remained perfectly quiet in the same position up to 7.53, depositing no more sperm, and then walked about the cage.

Cocooning.—The cocoon is a nearly globular bag, and the mode of making it was seen several times, of which these will serve as examples:

(1) ♀ No. 231 was observed on June 28, at 7.30 P.M., spinning a circular disk of silk ("base" of the cocoon) on the floor, close to the edge of a nearly evaporated drop of water. This base's diameter did not quite equal the length of her body. She was then brushing her spinnerets from side to side, and rotating her body at intervals. At first she made frequent pauses, but fewer as she proceeded, and gradually enlarged the diameter of the base until it quite equaled the length of her body. This continued until 8.15, when she changed the method of spinning, and started to build a silken wall upon the margin of the base; this she accomplished by elevating her spinnerets high in the air after each stroke, then applying them again close to the first point of

attachment of the threads, thus laying down looped threads. As she did so she rotated her body slowly, keeping the tips of her palpi pressed against the portion of the margin opposite the one to which she applied her spinnerets. So she formed a narrow marginal wall, low but quite visible to the naked eye, made entirely of looped threads. This was finished at 8.35. Then she stood so across the cocoon base that her palpi touched the wall in front and her spinnerets the wall behind, and oviposited upon the centre of the base. From her genital aperture fell a large drop of viscid fluid, its upper surface remaining adherent to her genitalia, and the yellowish ova dropped into it one by one. The oviposition lasted from 8.36 to 8.41, when she tore herself loose from the viscid drop and started to spin the cover of the cocoon. She spun over the egg mass uninterruptedly from 8.41 to 8.59, forming a dense covering and battening the silken wall down at the same time. From 8.59 to 9.01 she occupied herself with loosening the cocoon from the glass floor of the cage, doing so by seizing with her chelicera and pulling first one part of the edge of the base, then another, bracing her legs firmly against the ground, until she had completely loosened it. She then held it a moment attached to her spinnerets, then from 9.02 to 9.24 held it below her cephalothorax with her third pair of legs, revolving it in this position with her palpi, and spun upon its surface with abdomen flexed vertically downward. Thus was formed a perfect globular cocoon, white in color.

(2) ♀ No. 228 was observed at the close of the cocooning, which was like that of the preceding case.

(3) ♀ No. 229 did not spin the base of her cocoon directly upon the floor of the cage, but upon a scaffolding of threads inclined at a slight angle to the floor and joined to the wall. From 11.03 to 11.17 A.M. she was occupied in spinning the marginal wall, from 11.18 to 11.22⅓ in the oviposition, from 11.23 to 11.58 in making the covering (in the first part of which she elevated her spinnerets and did not brush them, thus preventing them from adhering to the viscid drop), from 11.58 to 12.02½ in tearing the cocoon loose, and from 12.05 to 12.30 in spinning upon the cocoon while held beneath her body.

These three were the only normal cocoon-makings observed. This species is peculiar in sometimes making the base of the cocoon without a preliminary scaffolding.

All the other cases resulted disastrously, due either to the spinnerets of the mother becoming clogged with the viscid substance surrounding the eggs, or, in most of the cases, to her making the mistake, when tearing the cocoon loose from the floor, of tearing the cover from the base, thereby leaving the egg mass exposed. In all these cases the first part of the cocooning and the oviposition proceeded normally; the mistake was in making the cover or in tearing the cocoon loose. And once a mistake in the progress was started none of these individuals were able to rectify it, though one tried for a few moments to spin over the rent in the cocoon, and each in conclusion chewed up either the imperfect cocoon or the eggs; when the cover was torn off the eggs, the spider would very frequently chance to break some of the latter, and once she tasted their contents she would eat them. They would seem perplexed after a cover had separated from the base, would remain still a long while, would feel with the palpi first the cover and then the egg mass on the base; usually they would take the isolated cover beneath the body and spin upon it there, as they do with a normal cocoon, but did so irregularly. An isolated cocoon cover was never carried attached to the spinnerets more than a short time. One spider had made her cocoon perfect except for a break at one point between the cover and the base; this resulted in an elongated, irregularly conical cocoon, which she dropped from her spinnerets after a few days.

Now the reason for such abnormal cocoons seems to be in a mistake made in tearing the cocoon loose; but there is still a reason back of this one, at least for some of the cases. It was my custom with these spiders, as with the other Lycosids, to put a drop of water upon the floor of their cages every day or two, for them to drink. Three of the miscarried cocoons whose making was observed, were commenced by spinning over the surface of this drop of water. The water in some way mingled with the silk of the cocoon, and at least contributed to making it a failure. Why they should spin over the water I cannot say, except that perhaps the feeling to the touch of the surface of the water may simulate the feeling of a silken layer, and so awaken reflexes to spin at that place. In any case, all the Lycosids and one Philodromid, which chanced to lay the base of their cocoons upon a water surface, made a failure of these cocoons. But in no other species have I experienced such a high percentage of failures as in *Lycosa stonei*.

The number of cocoons, and the dates, were as follows: ♀ No. 36, June 6, a failure; ♀ No. 165, June 25, a failure; ♀ No. 184, June 29, a failure; ♀ No. 227, June 27, July 16, both failures; ♀ No. 228, June 25, July 14, the second one a failure; ♀ No. 229, June 29, a perfect cocoon, but cut open too soon by the mother, so that the eggs rolled out; ♀ No. 230, June 27, July 14, both failures; ♀ No. 231, June 22, a perfect cocoon, but the mother destroyed it.

Care of the Young.—The mother carries the cocoon attached to her spinnerets, bites it open around the equator to allow the young to escape, then carries the latter upon her body for a few days.

Parasites.—One male and six females died from the effects of an endoparasitic dipterous larva. One spider contained two of these parasites, the others one each. After the parasite, whose bulk nearly equals that of the body of the spider, has eaten away most of the soft parts of the spider, it emerges through a hole it makes in the wall of the abdomen of the spider, and this emergence kills the host. It is strange that these spiders should live so long with such a huge parasite within them. A short time before the parasite escapes the spider acts in a peculiar manner, walking about spasmodically and often spinning aimlessly. The most remarkable case of this kind was the following: ♀ No. 237 occupied July 3 in spinning a completely closed, oblong sack, with a ength of 30 mm. and a greatest depth of 20 mm. This silken sack was placed in the angle between two vertical walls and the roof of the cage, and its contours were rounded where not in contact with the glass. This completed around her, she remained in it until the evening, when the large parasite emerged. An indirect explanation may be that lhe parasite irritated the nervous centres governing her spinning apparatus, she was thus instigated to spin, and it was merely a coincidence that she chanced to surround herself with a sack.

Two of the parasitic larvæ which emerged I kept until they perfected and developed into winged imagos. My friend, Mr. Charles W. Johnson, identified them as Acrocerids.

Lycosa ocreata pulchra Montg.

Individuals observed, males: No. 91, captured May 18, killed by ♀ No. 186, June 12; No. 110, captured May 19, killed May 31; No. 170, captured May 31, killed by ♀ No. 171, June 7.

Individuals observed, females: No. 92, captured May 18, moult July 12. killed July 12; No. 111, captured May 19, killed May 31; No. 171, captured May 31, escaped June 13; No. 186, captured June 10, still living; No. 317, captured July 14 (then with a cocoon), died October 4.

Moult.—On July 12 ♀ No. 92 was found on the floor of her cage, evidently dead; she was put in alcohol, but then moved vigorously, and the old skin on the dorsal side of her thorax separated off. Accordingly she was in the quiescent state of a beginning moult. The remarkable point of this moult was that on June 3 she had copulated—*i.e.* a copulation had preceded the last moult.

Mating.—The following cases were seen:

(1) ♀ No. 92. ♂ No. 91 was placed with her for three hours on

the night of May 18, but there was no attempt at mating; this was repeated during two hours on the following night, as also on May 28 and May 31. At 8.10 P.M., June 3, the same male was again introduced. She moved about at intervals, he avoiding her, up to 9.12. Then I chanced to look at another cage for half a minute, and when I looked back found the pair in copula. The position was the one usual for this genus, he above her with his head pointed toward the posterior end of her abdomen and his three anterior pairs of legs holding her tightly; his first patellæ were just behind her fourth femora, his second patellæ behind her third femora, his third patellæ behind her second femora. Only one palpus was inserted at a time; when his right palpus was used his head was turned obliquely over the right side of her body; when his left was used, over the left side. The sequence of usage of the palpi, the time, extent, and the number of times each was inserted before the other was used, was as follows (using the abbreviations *r* and *l* for right and left palpus respectively): r, 9.13–9.13½, the number of times not noted; l, 9.13½–9.14½, 3; r, 9.14½–9.15½, 3; l, 9.15½–9.17, 4; r, 9.17–9.19, 5; l, 9.19–9.21, 4; r, 9.21–9.23½, 5; l, 9.23½–9.26¾, 6; r, 9.26¾–9.29, 5; l, 9.29–9.33, 6; r, 9.33–9.37, 4; l, 9.37–9.41, 5; r, 9.41–9.43, 2; l, 9.43–9.47, 3; r, 9.47–9.50, 3; l, 9.50–9.53, 2; r, 9.53–10.02, 4; l, 10.02–10.04½, 2. He made each palpal insertion by reaching the palpus down and rubbing it against her epigynum, and while it was inserted a large sac evaginated from the side of the palpal organ; the palpus was kept inserted until this sac collapsed, a period of about 15 seconds in the earlier part of the copulation, and of 30–40 seconds in the latter part; then the palpus was withdrawn and rubbed against his mandibles. At the end of the copulation (which had lasted 52 minutes) the male rose and walked off, immediately proceeding to the act of sperm-induction.

(2) ♀ No. 111 was immature, and when ♂ No. 110 was placed with her they avoided each other.

(3) ♀ No. 171. ♂ No. 170 was placed in her cage May 31, and again on June 1 and 3, but no mating followed. On June 7 the same male was introduced at 8.49 P.M. From then until 8.51 they were motionless with their legs touching, when each backed off a little, he then in his characteristic attitude of defense, with his first pair of legs drawn up and back so that their patellæ touched the top of his cephalothorax. At 8.52 he quivered these legs, she made a step toward him, then both remained still with uplifted fore-legs. At 8.54 she made another short step toward him, not aggressively, *i.e.*, without uplifted fore-legs, but he backed off a little as before. At 8.55 he

made a short jump upon her, and quickly got into copulatory attitude, she motionless in his embrace. Their position was as in the case of ♀ No. 92.×♂ No. 91; the act lasted from 8.55 to 10.22 P.M., 1 hour and 27 minutes; the palpi were inserted alternately, the right 16 times and the left 15 times. Then he rose, she also started up quickly, chased and killed him within a few seconds, and ate him.

(4) ♀ No. 186 was pregnant when I introduced ♂ No. 91 on June 12, and she killed him.

In all these cases there was no sign of a courtship on the part of the male; after touching the female, he would raise his fore-legs in defensive attitude, and if she was desirous she would approach him with lowered fore-legs, otherwise she would try to kill him. Now there is a noticeable secondary sexual difference: the tibiæ of the first pair of legs of the male only are covered thickly with long, vertically implanted black bristles, making them look like miniature test-tube brushes. When the male stands before the female with these legs flexed, as he does, with the patellæ close to the sides of his cephalothorax and his body crouched near the ground, the tibiæ are more horizontal than inclined upward. This, then, is not the best attitude to exhibit them to the female; they would be best shown off if they were directed vertically upward. On this account, this bristling of the tibiæ can hardly be regarded as a sexual ornament that is exhibited to charm the female. Further, it may be noted that this position of the first pair of legs is also assumed by the female when roughly handled or frightened; it is an attitude of defense of the species, not of sexual exhibition. These bristles are possessed only by the mature males. I could not determine that they serve any particular purpose, though certainly they give these legs a firmer hold upon the abdomen of the female during copulation.

Sperm-induction.—♂ No. 91, immediately after his copulation with ♀ No. 92 on June 3, moved to another corner of her cage and spun upon the floor from 10.11 to 10.15. Then as he was interrupted by her approach, I separated her by use of the sliding partition. He commenced spinning again at 10.19, at the angle of a wall and the floor, brushing his spinnerets to and fro upon the glass, on the floor and on the wall, all the time beating the tips of his palpi upon the overspun area. This continued up to 10.32, when a fine covering of silk, barely visible with a hand lens, covered that part of the floor. At 10.32 he elevated his abdomen slightly, still standing over the silken covering, and discharged a minute globule of sperm from his genital orifice upon the silk sheeting. This globule rolled to the ventral surface of his sternum, and he then applied the tips of his palpal organs alternately to this part of his sternum, and rubbed them against it; this was evidently the process of taking the sperm into his palpi, though I could not see the drop at this time. This continued from 10.32 to 10.37, then he ceased, and did not repeat the process up to 11.40, when I ended the observation.

Cocooning.—This was seen only once. ♀ No. 186, on June 21, at 11.35 P.M., was found spinning on the floor in a corner of the cage, slowly and with frequent pauses. She soon ceased, but began again at 1.30, and at 1.50 had made, upon a scaffolding of lines passing from the floor to the wall and inclined at an angle of 40°, a white, circular silken disk, the base of the cocoon. The diameter of this base was about equal to the length of her body. She continued to spin upon it up to 2.27, but slowly and with frequent rests. In the earlier portion of this time the spinnerets were brushed from side to side, before backward rather than from side to side, and she rotated her body but little. In the later portion she spun mainly upon the margin of the base, and formed there a barely perceptible wall of curled threads made by elevating her spinnerets after each stroke, and rotated her body while spinning. She stood with the tips of her palpi and her first and second pairs of feet upon the edge of the silken disk (base), her other feet upon the surrounding scaffolding. At 2.27 she stood quiet over the base with her head turned toward its highest edge, discharged a large drop of yellowish fluid of viscid consistency upon the centre of the cocoon base, and, while the upper surface of this drop still adhered to her epigynum, dropped the ova into it one by one. At 2.31½ she started to break loose from this drop, but half a minute passed before she was able to do this, the surface of the drop adhered to her so firmly. At 2.32 she commenced spinning the cover to the egg mass with a brushing movement of the spinnerets, and; except for a pause from 2.35 to 2.37½, this continued up to 2.57. Thus the egg mass (within its viscid drop) was flattened down and was evenly covered with silk. The time from 2.57 to 3.01 was occupied in biting loose the margin of the cocoon from the surrounding scaffolding. The cocoon at this stage was lenticular, and the margin of the base projected beyond the cover. At 3.02 she held it beneath her cephalothorax, holding it there with her third pair of legs and slowly revolving it with her palpi and chelicera; at the same time she spun upon it, holding her abdomen bent vertically downward. She then fastened it to her spinnerets and so carried it about, spun on it for a short time again at 3.26, then hung it definitely to her spinnerets and was not seen to spin upon it any more that day.

The peculiar part of the above cocooning, in comparison with other Lycosids, was its slowness, pauses occupying more time than the spinning itself.

The number of cocoons, and the dates, were as follows for ♀ No. 186: June 21, this one did not hatch, but was chewed up by the mother; July 13, this also did not hatch.

Care of the Young.—The cocoon is normally carried attached to the spinnerets until it hatches. ♀ No. 317, who was captured with a cocoon, bit it nearly in two around the equator to allow the young to escape; the young took above four hours on July 15 in leaving the cut cocoon to get upon her body, and the first of them left her on the night of July 19.

Lycosa scutulata Hentz.

Individuals observed, males: No. 232, captured June 22, moulted July 11, killed by ♀ No. 273, August 21; No. 233, captured June 22, moulted July 2 and 18, killed by ♀ No. 271, August 25; No. 275, captured June 27, moulted July 14, killed by ♀ No. 273, August 25.

Individuals observed, females: No. 271, captured June 27, moulted July 1 and 20, still living; No. 273, captured June 27, moulted July 3, 14, 31, still living; No. 278, captured July 2, moulted July 3, died July 24 (then immature); No. 326, captured July 23, moulted July 24, still living.

Moult.—♀ No. 273 was found at the conclusion of the process at 10.30 P.M. The exuvia was upside down and attached by its feet to web-lines in the upper part of the cage; the spider was hanging attached to it by her spinnerets. She did not start moving until 10.42; at 10.57 she walked away from the old skin, and then remained quiet for half an hour more. The old skin breaks by a horizontal split, as in other spiders.

Mating.—The following cases were seen:

(1) ♀ No. 273. After her penultimate but before her final moult ♂ No. 232 was introduced in her cage on July 15, 16 and 18. Though he was still immature he courted her on all these occasions; and he courted her at frequent intervals when they were not together in one cage, recognizing her at a distance of several inches through the glass of the cages. When courting he held his body close to the ground, his last three pairs of legs stretched out nearly straight, but his first pair of legs were flexed at the femoro-patellar joint so that the femora were drawn back over his cephalothorax, the tibia and tarsus held nearly horizontally in the air. Then first, the palpi are swung outward and upward in alternation, each five or six times; second, one leg of the first pair is pushed forward and its foot tapped 6–10 times upon the floor in front of him, being

pushed forward a little after each tap, the abdomen twitching in time with the tapping of the foot; and, third, the leg is withdrawn and flexed over the cephalothorax again. This process occupies from 10 to 15 seconds, then there is a short pause, followed by a repetition of the act in which the opposite leg is pushed forward. This may be repeated several times without his moving from one spot, and not only when he is not facing the female, but also when he is at some distance from her. When he is facing her, and evidently sees her, while courting he advances toward her, taking a very short step forward during each act of courtship; sometimes he may advance as much as 2 or 3 millimeters at a time, sometimes again by still smaller steps, the rate increasing somewhat as he comes nearer to her. In case the female moves away in a course at right angles to his line of vision, he quickly turns around to keep her in view, but does not hasten his slow advance. I have also seen males when in their own cages, and out of all view of a female, commence to make these courting motions, even to continue them for some hours; but unless the female is in view, they do not advance while courting. This immature female, while being courted, plainly saw him, and would move away from him without his touching her; she made no determined hostile rushes upon him, and he did not appear afraid of her. Sometimes she assumed an attitude of defense, the long axis of the body at an angle to the floor with the spinnerets touching the floor, and the first and second pairs of legs elevated and stretched out before her. On July 31 she completed her final moult, and on August 1 the same male was introduced at 9.20 P.M., and kept in until 10.30; he courted, but she avoided him. He was introduced again on August 21, at 10.33 A.M., saw her at 10.36, and immediately commenced courting; at 10.38 she turned to face him and touched him with her fore-legs, when he immediately climbed over her head, embraced her and commenced the copulation. The attitude of the embrace was the same as in other Lycosids—the male above the female facing in the reverse direction, his head above the pedicel of her abdomen, grasping her with his three anterior pairs of legs; the female with legs outsprawled, and making only the movement of flexing the ventral surface of her abdomen upward on its long axis so as to bring her epigynum within reach of his palpal organ. The male lies rather obliquely across the female so as to extend his palpal organ downward to reach the epigynum; when he lies obliquely across her right side he employs his right palpal organ only, when across her left side his left palpal organ. During the time of each palpal insertion a large sac on the median side of the palpal tarsus swelled up, and the palpus was not withdrawn until this sac had collapsed; when a palpal organ was withdrawn it was each time drawn through the chelicera before it was inserted again. The following figures give the details of the copulation, *r* and *l* being used for right and left palpus respectively, and the numbers giving the time duration: r, 10.39¾–10.41; l, 10.41–10.41¼; l, 10.41½–10.42; r, 10.42–10.42½; l, 10.43–10.43⅕; l, 10.43½–10.44; r, 10.44½–10.44¾; l, 10.45–10.45½; r, 10.45½–10.46; l, 10.46½–10.47; r, 10.47⅕–10.47¼; r, 10.47½–10.48⅓; r, 10.48½–10.49; l, 10.49½–10.49⅞; r, 10.50–10.50⅛; l, 10.50½–10.51; r, 10.51⅖–10.51¾; l, 10.52–10.52⅕; r, 10.52¼–10.53; r, 10.53½–10.54; l, 10.54⅓–10.54⅘; l, 10.55¼–10.55½; l, 10.55¾–10.56; r, 10.56⅕–10.56⅗; l, 10.57–10.57⅕; r, 10.57½–10.57⅗; l, 10.57¾–10.58⅖; r, 10.58–10.58⅞; l, 10.59–10.59¼; r, 10.59½ (2 seconds); r, 10.59¾–11.00; l, 11.00¼–11.00¾; r, 11.00⅞–11.01¼; l, 11.01½–11.01¾; r, 11.02–11.02⅓; l, 11.02½–11.03; r, 11.03⅐–11.03⅖; l, 11.03¾–11.04; r, 11.04⅒–11.04⅖; l, 11.04⅞–11.05; r, 11.05⅒–11.05½; l, 11.05⅗–11.06; r, 11.06⅛–11.06⅖; l, 11.06⅗–11.07; r, 11.07⅒–11.07⅓; l, 11.07⅗–$11.07\frac{9}{10}$; r, 11.08–11.08⅓; l, 11.08½–11.08⅞; r, 11.09–11.09¼; l, 11.09½–$11.09\frac{9}{10}$; r, 11.10–11.10⅓; l, 11.10¾–11.11; r, 11.11⅐ 11.11⅜; l, 11.11½–11.12; r, 11.12⅒–11.12⅓; l, 11.12½–$11.12\frac{9}{10}$; r, 11.13–11.13¼; l, 11.13½–$11.13\frac{9}{10}$; r, 11.14–11.14½; r, 11.14⅛–11.14⅗; l, $11.14\frac{9}{10}$–11.15⅕; r, 11.15⅓–11.15¾; l, 11.16–11.16⅕; r, 11.16¼–11.16⅖; r, 11.16⅗–11.16¾; l, 11.16⅞–11.17⅒; r, 11.17½–11.17¾; l, 11.17⅞–11.18⅕; r, 11.18¼–11.18½; r, 11.18½–11.18⅞; l, 11.19–11.19¼; r, 11.19½–11.19⅞; r, 11.20⅒–11.20⅑; l, 11.20¼–11.20⅗; r, 11.20⅞–11.21 $_1$; l, 11.21⅓–11.21¾; r, 11.21⅞–$11.22\frac{1}{12}$; l, 11.22¼–11.22¾; r, 11.23–$11.23\frac{1}{12}$; l, 11.23⅓–11.23¾; r, 11.23⅞–11.24⅒; l, 11.24⅜–11.24⅞; r, 11.25½–11.25⅞; l, $11.25\frac{9}{10}$–11.26⅕; r, 11.26⅗–11.26¾; l, 11.26⅞–11.27⅛; r, 11.27⅕ (10 seconds); r, 11.27⅞–11.28; l, 11.28⅙–11.28⅗; r, 11.29–11.29¼; l, 11.29½–11.29⅞; r, 11.30–11.30½; r, 11.30⅕–11.30¼; l, 11.30⅖–11.30⅞; r, 11.31⅖–11.31⅗; he then revolved upon her; l, 11.32½–11.32⅞; r, 11.33¾–11.34⅕; r, 11.35⅗–11.36; l, 11.37–11.37⅖; r, 11.38⅕–11.38⅗. Then he moved off her, when she jumped at killed and ate him. On August 25 ♂ No. 275 was introduced, but she caught and ate him too.

(2) ♀ No. 271 completed her final moult on July 20, and on August 22 ♂ No. 233 was dropped upon the floor at 7.28 P.M., while she was upon the wall. He saw her at a distance of 75 mm., but she was placed so that she could not see him, so at 7.35 I pushed her to the floor. He courted and slowly approached her; she made an aggressive movement; he dodged her but continued courting. She approached and touched him, whereupon he immediately got into copulatory

position and commenced the coition. The postures and the mode of copulation were as in the preceding case; the right palpus was employed 84 times and the left 81 times. This copulation began at 7.38 and ended at 8.32⅞, when she struggled beneath him and he cautiously moved away from her, when I put him into another cage. On August 25 the same male was put with her again, at 2.42 P.M. He courted her steadily, though she made several jumps at him, and he even followed her up the wall still courting. At 4.05 I was obliged to leave, and returning at 4.28 found them in copulation, which continued up to 5.03, when she struggled and he left her. She did not attempt to kill him at first, and he followed her still courting; but about two hours afterward she killed and ate him.

(3) ♀ No. 278 was not fully mature. ♂ No. 275 was placed with her for half an hour on July 16; they grappled, and after that remained quiet. On July he was introduced again and began courting at 5.02, as soon as he saw her, but she ran from him.

(4) ♀ No. 326 finished her final moult on July 24. ♂ No. 275 was placed with her on July 25 and 26, but courted for only a short while each time. There was no courtship at all on July 30 and August 22.

There is, accordingly, in this species a decided courtship; the male differs from the female in his smaller size and in the black color of a portion of his fore-legs, and these legs (and the palpi also) are moved in a particular manner during the courtship. Observation shows that the male recognizes the female as such at a distance of at least six inches. The male's approach to the female is very slow, a kind of creeping, not at all similar to the vehement approach of certain other Lycosids. The male will court immature females. The female, if eager, gives the signal of willingness to the male by touching him lightly with her first pair of legs, when he immediately embraces. In the observed cases, with one exception, the female killed the male at the end of the copulation. The peculiarity of the copulation is that the right and left palpi are inserted in the epigynum in almost strict alternation, that these insertions are very brief and numerous, and that the intervals between them are markedly short. One female copulated twice with the same male at an interval of three days. The time duration of the longest copulation watched was 59 minutes, of the next longest 55 minutes.

Cocooning.—♀ No. 271 made a cocoon in the second week of September, carried it attached to her spinnerets (the normal way) and is still carrying it. ♀ No. 273 made her cocoon during the first week of September, but dropped it from her spinnerets about the 25th of that month, and did not take it up again, although she frequently touched it; she had not bitten it open before dropping it. The cocoons are nearly globular, white or bluish; their architecture shows them to be composed of two portions, a base and a cover, as in other spiders.

Webs.—All the males spin irregular sheet-like webs inclined at an angle of about 45° to the floor and the wall of the cage. One female also slowly built up an irregular horizontal web. The other species of *Lycosa* observed did not make such webs, but simply short lines to attach themselves to the vertical glass walls of the cages.

Lycosa nidicola Emerton.

Care of the Young.—Six females of this large species were kept; three of them were captured carrying cocoons, while one, after her final moult (which was like that of other Lycosids), formed the base of a cocoon upon a drop of water and oviposited upon it, but this cocoon was a failure.

The large globular cocoon is carried dependent from the spinnerets until it hatches. The mother helps herself in supporting its weight, sometimes by resting it partially against the tarsi of her fourth pair of legs, sometimes standing with her abdomen and the third and fourth pairs of legs upon the wall of the cage, whereby the cocoon rests against the wall. She cuts open the cocoon to allow the escape of the young, then carries the young upon her for a considerable length of time, one female for 11 days, another for 13 days, another for 14 days—longer periods than were observed in other Lycosids. The number of young is also large; in the two cases where they were counted they were respectively 210 and 302 in number. The following notes may be of some interest:

♀ No. 212 was seen on June 23, at 2.00 P.M., holding her cocoon beneath her cephalothorax with her first and third pairs of legs and her palpi, and tearing its lining with her chelicera; she had then scraped away some of the superficial layer along an equatorial line, and at one or two points in this line her chelicera had penetrated to the interior. At 2.22 the first of the spiderlings crawled out through one of these holes, and as soon as the mother felt its motion she quickly fastened the cocoon to her spinnerets and waited patiently. But no more spiderlings emerging, she bit the cocoon again from 2.43 to 2.52, when she suspended it again to her spinnerets. At 3.34 the second and third spiderlings crawled out upon her body, and at 3.39 the fourth. The mother apparently divined that the young were not emerging rapidly enough, and bit the cocoon again from 3.48 to 3.55. At 3.59 the fifth spiderling climbed upon her, at 4.03 about eight more spiderlings, and at 7.00 there were about twenty upon her. Next day at 9.00 A.M. more young were still emerging, and at 3.00 P.M. she dropped the cocoon (empty of young) from her spinnerets. The young massed together upon her abdomen and cephalothorax made her appear twice her natural size; she did not allow them to get upon her eyes, however, but brushed them away gently with her palpi. On July 2 the first of the spiderlings left her, running down her legs to the ground, and on July 4, when I killed her, only five were left upon her; these I endeavored to rear by keeping them in separate tubes, but all of them died within a few days.

♀ No. 211 was found on June 16, at 2.45 P.M., resting her cocoon (attached to her spinnerets) upon the floor; some of the young on emerging from the cocoon got upon the floor, but these quickly climbed up the legs of the mother. She dropped the cocoon next day, and examination showed that she had gnawed it along its whole circumference, but at only certain points along the line of the abrasion had holes been made to the interior cavity. In this case, as in the preceding, the young that had left the mother's constructed a network of silken lines through the cage; possibly aeronautic lines, such as young Lycosids normally employ to carry them, with the help of the wind, away from the home of the mother.

Lycosa punctulata Hentz.

One female of this, locally rather rare, species was kept and observed from June 10 until her death on August 3.

Cocooning.—On July 1 and 2 she was found spinning upon the floor of the cage. On July 3, at 11.00 A.M., I found she had quite a thick sheeting over the floor and for a little distance up the sides of the cage, covering an area of about 25 x 65 mm. At 1.33 P.M. on that day I found she had constructed an oval disk of white silk (cocoon base) with a diameter about equal to her body length; this base was placed upon the preliminary scaffolding in the corner, and inclined to the floor at a slight angle. From 1.33 to 1.46 she spun a silken wall upon the margin of this base, though when finished it was barely visible to the naked eye. She composed it of looped threads, made by uplifting her spinnerets high at each stroke. She then stood over the centre of the base, and from 1.47 to 1.50 there fell upon the center of the base from her genital aperture a clear drop of viscid fluid, into which fell in succession a number of pale yellowish ova; a second smaller drop from 1.51 to 1.52; and from 1.52 to 1.53 five small drops in succession, each enclosing one ovum. All the drops merged together upon the cocoon base, but the whole mass was small in proportion to her volume, and evidently she had not deposited all the ova within her since her abdomen was still quite distended. At 1.53½ she commenced spinning the covering, with high strokes of the spinnerets laying down threads that were looped, since a second attachment of the spinnerets would be close to a first; but she placed very few of these over the egg mass, spinning mostly upon the margin of the cocoon base and even upon the foundation beyond it. She spun very slowly, occupied most of the time in pauses, and occasionally walked about the cage. At 2.23, when the egg was only imperfectly covered with a thin silk layer, she loosened with her chelicera about a quarter of the edge of the base from its moorings. She rested, and at 2.27 seized the covering of the egg mass, pulled it, then rested, holding it in her jaws. From 2.35 to 2.37 she spun again upon the margin of the base, then turned about, seized the egg mass with her jaws, began to eat the eggs, and devoured them all by 3.10. Finally, with her chelicera she tore the base completely loose, and ate up that too.

Though this cocooning was a miscarriage, due to faulty oviposition and to insufficient covering to the eggs, yet the method followed would indicate that this species normally cocoons like others of the genus.

Lycosa lepida (Keys.).

Individuals observed, males: No. 150, captured May 26, died early in September; No. 200, captured June 10, died August 15; No. 201, captured June 10, died July 26.

Individuals observed, females: No. 183, captured June 10, died October 12; No. 193, captured June 18, moulted June 18, died October 18; No. 194, captured June 10, died July 5; No. 196, captured June 10, still living; No. 197, captured June 10, still living; No. 203, captured June 10, with a cocoon, killed August 3; No. 214, captured June 10, with a cocoon, died in November; No. 268, captured June 27, died October 2.

Moult.—The old skin splits along the horizontal line as in other spiders.

Mating.—♂ No. 150 was introduced to ♀♀ Nos. 194, 268, 203, 193, 197; ♂ No. 200 to ♀♀ Nos. 194, 197, 203, 268; ♂ No. 201 to ♀♀ Nos. 196, 194. No copulation occurred in any case before or after cocooning, and all the females except two were pregnant when captured.

The following observations point to a simple courtship on the part of the male, who is more brightly colored and considerably smaller than the female:

(1) ♀ No. 194. When ♂ No. 201 was placed with her for the second time, he got behind her and shook his fore-legs slowly in the air, these

legs held outstretched before him and elevated only slightly from the ground. This is an action of neither aggression nor fear; aggression is evidenced by standing high upon the legs and stretching out the first pair of legs without shaking them; fear, by holding the body low, and flexing the first pair of legs at the tibial joint back over the cephalothorax.

(2) ♀ No. 196. ♂ No. 201 was put in her cage at 4.47 P.M., June 12. At 6.00 P.M. they faced each other at a distance of about 50 mm.; his body was flat upon the ground, and at intervals he raised his fore-legs, which were stretched out on the floor before him, and shook them tremulously in the air. After several repetitions of this movement he approached her slowly and touched her, making a short step forward with each shaking of his legs, but she rebuffed him.

Cocooning.—The following cases of normal cocooning were seen:

(1) ♀ No. 183 had been caught in a test-tube, and before she was removed to a cage she had made her cocoon there. At 1.10 P.M., when first noticed, she had already laid her eggs upon a silken cocoon base, the diameter of which about equalled the length of her body, and was then spinning the cover by brushing the spinnerets from side to side, at the same time rotating her body over it. From 1.21 to 1.23 she occupied herself with biting the margin of the lenticular cocoon loose from its scaffolding At 1.25 she held the cocoon beneath her cephalothorax, when she was placed in a larger bowl for better observation. There she walked about with it attached to her spinnerets until 1.28, then held it beneath her cephalothorax again with the use of her third pair of legs, and while rotating it with her chelicera and palpi she spun upon it with the abdomen bent downward. This continued until 1.55, when she attached the now round cocoon to her spinnerets.

(2) ♀ No. 196, on June 14, at 5.45 P.M., commenced spinning on the floor of the cage with many interruptions and uncertainly. At 6.55 she commenced again in a corner of the cage, brushing her spinnerets over the floor and the wall, and turning her body sometimes from right to left and sometimes in the reverse direction. Gradually her spinning became more regular, with fewer pauses, and she constructed a nearly circular sheet of close web elevated from the floor to the wall and with a central depression extending to the floor. Up to 7.37 she spun upon this foundation the base of the cocoon, a white, circular disk a little less in diameter than the length of her body, this base (like the supporting scaffolding) rising from the floor to the wall at an angle of 30°. Then from 7.37 to 7.54 she occupied herself

with making a marginal wall upon the base, and did this by laying down looped threads (made by high strokes of the spinnerets); the maximum height of this wall about equaled the diameter of her abdomen, and it was not quite vertical, but inclined slightly toward the centre. She then stood over the base with her head toward its highest margin, and from 7.54 to 7.57 oviposited upon its centre; from her genital aperture fell first a large drop of clear, viscid substance, then a smaller drop containing one ovum, then a large drop into which fell in rapid succession 17 ova; finally a slowly-exuding, thread-like stream of the viscid substance, contained in which were ova arranged one behind the other. All this fluid substance was kept from overflowing the base by the marginal wall. Next, from 7.57 to 8.12, she spun a cover over the egg mass, plastering thread after thread upon it; the cover was of less diameter than the base. From 8.12½ to 8.17 she bit loose the margin of the cocoon, and when a cut had been made pried up the edge with her palpi. The loosened cocoon was now of a lenticular shape, and she took it below her thorax (not holding it off the ground, it was too large for that), and revolved it in that position with her palpi, chelicera and third pair of legs; she spun vigorously upon it so that it soon assumed the definite globular form, and only a line around it marked the point of union of the cover to the base. The cocoon was at first white, but became bluish on contact with water.

The other cocoons made resulted in failures, though the commencement in each of the two cases observed was normal. Thus ♀ No. 196, in making her second cocoon, spun the circular base, built a marginal wall (of a height of 2 mm.) upon it, oviposited upon it from 8.17 to 8.20 (71 ova dropping in succession into one large drop of viscid substance), and spun the cover from 8.20 to 8.24. Then she changed the normal process, and for a minute stopped to loosen a portion of the cocoon from the ground, then spun upon the cover again from 8.27 to 8.34. She then took the cocoon beneath her body and began spinning upon it, but the covering had been made too thin; she was evidently puzzled by feeling the ova through it, and worked hesitatingly; she hung the misshapen cocoon to her spinnerets, but before next morning had devoured it and the enclosed ova. She had not been able to compensate for the initial mistake of spinning too thin a cover. ♀ No. 268 started to spin upon a drop of water that I placed on the floor of the cage; I drained off the water and she ceased. Next day I put in another drop; she first spun over it, then oviposited on it, but the water caused the ova to disintegrate and she finished by eating them.

The water evidently instigated her to the cocooning, yet in natural conditions these spiders do not appear at all aquatic, for I have found them on rather dry ground under stones and logs.

The number of cocoons made, and the dates, were as follows:

(1) ♀ No. 183: June 11, hatched July 5.

(2) ♀ No. 193: July 25, a failure.

(3) ♀ No. 196: June 14, hatched July 10; July 2, a failure. Two cocoons.

(4) ♀ No. 197: June 12, dropped by the mother and did not hatch; July 13, dropped also after the mother had bitten it open prematurely; August 10, dropped August 30. Three cocoons.

(5) ♀ No. 203 was caught with a cocoon that hatched July 1.

(6) ♀ No. 214 was caught with a cocoon that hatched July 5.

(7) ♀ No. 268: July 20, a failure.

Care of the Young.—As in other species of the genus, the cocoon is carried by the mother attached to the spinnerets, and she bites it open to allow the young to emerge, when they get upon her body, and about a day afterward she drops the cocoon. Sometimes, as the above list of cases shows, the mother drops the cocoon before it hatches; in all such cases this appears to be due to the mother biting open the cocoon prematurely, and true to her instinct she drops the cocoon after opening it; when the cocoon is opened too early, the ova do not develop further. The mother is very tenacious of the cocoon. I have seized a cocoon, when attached to the mother, with forceps and shaken it, with the mother, violently in the air, without dislodging her hold upon it; there is, in the case of older cocoons, a very hard and thick thread attaching them to the spinnerets. One mother I watched when she was bending down to drink; about half of the young upon her climbed down to the water and drank of it also, but quickly returned to her when she commenced to move away. In changing this mother from one cage to another, a great mass of young was dislodged from her back and fell upon the floor. Some of these young ran about and would not return to the mother when they came in contact with her, but the remainder clung together in a mass upon the floor. The mother seemed excited, yet when she touched the mass of young she would remain by it only a short extent of time, and did not aid the young to return to her. But next day all were upon her back again.

Lycosa verisimilis Montg.

Parasites.—The type specimen of the female of this species was kept alive some time, until she was killed by the escape of a large species of *Mermis*. Three days preceding she dropped the large globular cocoon that she was carrying attached to her spinnerets, and 6 parasitic wingless hymenoptera emerged from two circular holes in the cocoon; they had killed all the young spiders that had been contained in it. Prof. William H. Ashmead, Assistant Curator in the U. S. National Museum, kindly identified this parasite as *Pezomachus dimidiatus* Cresson (an Ichneumonid).[2]

Lycosa charonoides Montg.

Care of the Young.—The type individual of this species was caught May 31 with a globular cocoon hung to her spinnerets; the cocoon was apparently newly made because it was light in color, and on the evening of the same day she held it below her and spun upon it in the manner characteristic of the genus. On June 15 I found the cocoon lying on the floor, with a hole made by the mother along about a third of the equator; within the cocoon were about 20 dead spiderlings, while a number of living ones were clustered upon her abdomen and one or two running upon the floor; the young left her back gradually, some remaining upon her until June 26.

Pardosa nigropalpis Emerton. Pl. V, figs. 8, 9.

Individuals observed, males: No. 32, captured May 4, died next day; No. 35, captured May 4, killed May 15; No. 38, captured May 5, died May 29; No. 55, captured May 6, died May 15; No. 56, captured May 6, escaped May 12; No. 59, captured May 6, killed May 19; No. 60, captured May 6, escaped May 18; No. 62, captured May 6, killed May 11; No. 64, captured May 6, died (from thirst) June 5; No. 172, captured June 1, died June 11.

Individuals observed, females: No. 33, captured May 4, died August 15; No. 54, captured May 6, died August 15; No. 57, captured May 6, still living; No. 58, captured May 6, died August 9; No. 61, captured May 6, died June 14; No. 63, captured May 6, died August 15; No. 65, captured May 6, died August 15; No. 152, captured May 26, died (from effects of parasitic *Mermis*) June 11; No. 177, captured June 1, escaped August 9.

Mating.—This was studied by placing a male with a female only during the time of observation, keeping them separated at other times; a partition cage was used, or else the male was carefully dropped into the cage of the female.

This is the most abundant local Lycosid, and by collecting vigorous individuals in the spring, when the males are very numerous, and selecting those females which are not gravid, the courtship may be readily observed.

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[2] Prof. Ashmead, in a personal communication, states that a considerable number of parasitic hymenoptera have been reared from the eggs and cocoons of spiders, and names the genera *Bæus*, *Acolus*, *Acolvides*, *Polysphincta*, *Epiurus*, *Pimpla*.

The advances are made by the male, and there is a distinct courtship process, which a vigorous male may maintain for two or three hours at a time with few interruptions when the female is recalcitrant. In natural conditions a large number of individuals often occur together on a limited area of ground, such as a moist open spot in a meadow; here probably the male does not make so prolonged a courtship, but on finding one female not eager or aggressive he probably seeks another. The males are somewhat smaller than the females and considerably weaker, but they are also quicker, so that they can generally escape from an aggressive female. There is a marked sexual color difference, the male being deep black and the female more brownish. Gravid females are always hostile to males, and once that such a female has made a determined rush at a male he usually ceases to court her, or when he recommences does so hesitatingly. The male recognizes a female as such immediately on touch; whether he recognizes her by sight alone I cannot tell. In courting a fleeing female the male appears to follow her mainly by sight, but even then he does not appear to find her by sight unless she is moving; often in his excited march for her he will run right past her without seeing her. But when one of his legs touches a part of her, he immediately reacts by quickly moving back a short distance and, after a brief interval, commences his courting motions with great vigor. These motions he will also continue sometimes for a considerable period after the female has been removed from the cage. In a double cage with a transparent glass partition, a male in one compartment and a female in the other, I have not seen a male court a female, though he certainly sees her through the partition; probably, then, it is touch of a female that impels him to courting activity.

The courtship motions are as follows: The male stands with his body well elevated above the ground (an attitude that a female takes only when she is aggressive) on his three posterior pairs of legs, his head higher than his abdomen, so that the long axis of his body describes an angle of 30°–40° with the surface of the ground. He waves his palp upward in the air (*i.e.*, straightening them out before his head) and flexes them outward, from one to three times, then draws his body slightly backward and downward, rapidly waving in the air the outstretched palpi and first pair of legs, and spasmodically shaking the whole body with the violence of the movement. The vehemence and to some extent the attitudes reminds one forcibly of a small terrier barking at a cat. The movement of the palpi exhibits most clearly their relatively huge, black terminal joints. When the male is timid, or not very eager, he may wave only his palpi, and these slowly and alternately instead of together. The male repeats these motions several times, usually becoming more vehement each time, then moves a step nearer the female, repeats them again, moves nearer again, so that in a short time his outstretched shaking fore-legs come in contact with the female. A virgin female usually flees before him before accepting him, he eagerly following and repeating his motions, even when he is not facing her. A female who has been fertilized and is pregnant, first menaces him by slowly uplifting and straightening out her first pair of legs toward him; and if this does not suffice to make him desist, she jumps at him when he comes too close. In the latter case the male frequently escapes by leaping over the female. The male seems the very incarnation of violent passion, and his whole body shakes with it; only when the female is so aggressive as to shake him, does he show distinct fear and cease his motions; and if a male has been so cowed by a female, and is immediately placed with another female, he will at first avoid the latter also, this being a good example of memory.

The following data will show the length of time of such courtship, the male in each case having been removed from the female at the end of the period of observation, and it being understood that copulations were enacted only when stated.

♀ No. 33. Put in ♂ No. 32 for nearly two hours on May 4, no courtship. ♂ No. 38 for an hour next day, no courtship. ♂ No. 38 in the evening of May 5, courtship for one hour. May 6, ♂ No. 38, courtship for half an hour in the morning, but none in the evening. ♂ No. 38, courtship of one hour on May 7. The same ♂ would not court on the following day, though she walked over him twice (evidently an invitation to copulation); immediately afterward ♂ No. 35 was put in and courted for half an hour, then repeated it at intervals. May 11, ♂ No. 35 was put in for the whole evening, but there was no courtship, although she displayed no hostility; nor would he court on May 12. On May 12 ♂ No. 64 courted with few interruptions from 1.40 to 3.00 P.M., and from 4.00 to 4.35. May 13 and 14 ♂ No. 64 courted intermittently. May 15 he courted actively from 8.00 to 10.15 P.M., again on May 16 from 3.00 to 6.00 P.M., on May 17 from 7.20 to 10.00 P.M., on May 18 from 7.00 to 10.00 P.M., on May 19 from 2.00 to 4.00 P.M. and from 8.15 to 11.15 P.M., on May 24 for two hours in the morning, on May 25 two hours in the afternoon, May 28 for about an hour, May 31 for more than an hour. After that this female became still more aggressive, and made her cocoon on June 10; she had evidently been fertilized before her capture.

Data could also be given, and I have them in full, for the other females kept, but this case is sufficient to show the persistence of the male in his courtship, and the preference of the female for particular males.

The process of copulation was seen only twice, namely ♀ No. 63 with ♂♂ Nos. 62 and 173. May 8 I placed ♂ No. 63 in her cage at 5.00 P.M., and at 5.15 he commenced his courtship and continued it until 6.00, pursuing her about. About 6.05 they came face to face, and remained so motionless until 6.24. Then he slowly reached out his first pair of legs and touched her abdomen, when she depressed her body to the floor (otherwise in her usual attitude); he walked over her head from in front and took a position upon her so that his head was pointed in the reverse direction of hers, his chelicera immediately above the pedicel of her abdomen, while the pedicel of his was above her head. The female with her head almost touching the floor, abdomen slightly deflected upward, and legs flexed rather closely to the body; the male embracing her closely around the cephalothorax with his second and third pairs of legs, the feet of the other pairs resting on the ground. This embrace was maintained and the female remained motionless through the whole process, from 6.25 to 6.34. The palpi were applied to the epigynum one at a time, as follows: The long axis of the male made a small angle with that of the female (both seen directly from above), so that his head region came to lie a little to one side of as well as above the pedicel of her abdomen. When his left side was thus turned toward the left side of her body, both his palpi were thrown over on that side of her also, but only the left palpus (the one closest to her) was applied; when his right side was inclined toward her right side, both his palpi were also placed on that side of her, but only the right one applied. When he used the right palpus she flexed her abdomen on its long axis so as to bring the right epigynal aperture more dorsal; when he used the left palpus, she would similarly flex the left side of her abdomen dorsad. One palpus would be applied to the epigynum several times in succession, after each application being withdrawn and worked with his chelicera; then the other palpus would be similarly used, after he had inclined his body toward her other side. The palpi were thus alternated several times. At 6.34 the female rose suddenly, assumed a hostile attitude, and the male ran off.

On June 1 I introduced ♂ No. 173 at 2.38 P.M. to the same female. He started immediately to court; she for a minute held her first pair of legs elevated in the air (attitude of guard and hostility), then depressed them and also bent her head to the floor (copulation attitude), but he discontinued courtship, and she moved away. At 2.42 he courted again, and she again depressed her head to the ground (her fourth pair of legs stretched out behind her, her other legs flexed to her sides) at a distance of half an inch from him; he then faced her for two minutes without courting, but he recommenced his courting at 2.44, and at 2.45 walked upon and embraced her, in the attitude previously described. The left palpus was then applied to the epigynum 6 times from 2.45 to 2.46, then the right palpus (on the right side of her body) 18 times from 2.46 to 2.52½. On each application the palpus was first rubbed against her epigynum, and when inserted a large clear sac, an evaginated portion of the palpus, swelled up and slowly (in 20 to 25 seconds) collapsed; after its collapse he withdrew the palpus and rubbed it against his chelicera for 2 or 3 seconds, then applied it again to the epigynum. At 2.52½ the female rose quickly, shook him off, and stood in hostile attitude, repelling several further attempts to copulate. No oviposition intervened between these two acts of copulation.

Cocooning.—This process was observed several times. In captivity it takes place at night, generally in the hours between 9.00 P.M. and midnight; though the earliest preliminary spinning frequently begins some 24 or more hours before. The following case is a good illustration of the method as observed in glass cages without earth:

♀ No. 54, on May 19, at 9.20 P.M., was first seen to be spinning, fastening threads (inclined at an angle of about 45°) from one vertical wall to the floor, and from the opposite vertical wall to the floor; at each wall was then a line of such parallel threads about a quarter of an inch long. This was a rather slow process, she taking often several seconds to attach each thread, and sometimes pausing to rest for a quarter of a minute. At 9.50 she started spinning the base of the cocoon on the scaffolding of lines placed against the right wall, not again returning to that on the left wall. The circular disk constituting the "base" of the cocoon was made by spinning upon a circular area of the scaffolding, at about the middle level of the latter; it was made discoidal in form by the female pressing the tips of her palpi upon one edge of the area, spinning upon the opposite edge, then rotating her body on its middle point as an axis. This was first done very slowly, but at 9.59 she began spinning more regularly, brushing her spinnerets (without elevating them) back and forth over the area, at the same time rotating her body, so that gradually a well-marked white disk was laid down upon the scaffolding, its diameter not quite equalling the length of her body; the scaffolding around the disk served as a support for her feet. The making of this base continued until 10.24. Then she stood above it with her head directed toward its upper end, and deposited upon the centre of the base from her genital aperture a large viscid drop of a transparent fluid; and into this drop, the upper surface of which still adhered to her body while its lower surface rested on the silken disk, there fell in succession about 13 large ova, easily seen by their yellow color within the viscid drop. This discharge of drop and ova did not exceed two minutes. Then at 10.26, before the upper surface of the drop had become fully loosened from her genital aperture, she commenced rapidly spinning across the drop, brushing the spinnerets from side to side and occasionally rotating the position of the body until she covered it with an evenly thick coating of white silk. This coating compressed the drop to the form of a flattened hemisphere; the supporting base being still flat, and quite a broad margin of it not covered by the upper covering of the cocoon. At 10.40 she commenced to bite the cocoon loose from the scaffolding, taking about 4 minutes in the process; when completely loosened it had the form of a biconvex lens. She then seized and held it beneath her cephalothorax with her third pair of legs, which like a pair of axles were first applied to its rounded sides, and revolved it by pressing on its edge with her palpi. While doing so, she held her abdomen bent vertically downward, so as to bring the spinnerets against the edge (equator) of the cocoon, and by spinning cemented down the overlapping margin of the base of the cocoon to its cover; it will be recalled that the covering of the cocoon was of less diameter than the base. Gradually and slowly the cocoon was rotated in other directions also, still held below the cephalothorax above the floor, the extended spinnerets brushing back and forth across its surface. At 10.50 the cocoon was observed to have changed from a glistening white to a lead-blue color (its final color is dark blue or dark gray); this may be produced by a difference in the silk, or perhaps by a secretion from the mouth. At 11.12, when I ceased observations, she was still busy spinning upon the cocoon. It had now become much more nearly globular, the definitive shape, and trace of a line around its greatest diameter was all left to show that it had been formed of two halves cemented together.

The first cocoon of ♀ No. 57 was made on May 12. At 4.50 P.M. she was found working upon the discoidal base (there had been no trace of it less than an hour before), and continued until 5.06. Then followed the oviposition, lasting not quite 2 minutes, in exactly the same manner as in the preceding case, except that 33 or 34 ova were discharged into the viscid drop. The ova sank one by one into this drop so as gradually to fill it and increase its size, but by virtue of its viscidity it still retained its globular form and surrounded them all. At 5.08 she started spinning the cover, finished it at 5.20, and in the time from 5.21 to 5.25 cut the cocoon loose from its scaffolding by tearing the surrounding threads with her chelicera. She then brought the cocoon below her cephalothorax and spun upon it; at 5.28 suspended it from her spinnerets and ran about, and at 5.34 spun upon it again. The fact that her cage had been kept in a dark drawer might account for the cocooning in the afternoon. For her second cocoon (finished July 3) she commenced the scaffolding on July 2. On July 3, at 9.50 P.M., I found her in process of finishing the circular base, and here I observed an action that I had probably overlooked in the case of the other cocoons; when the white discoidal base was clearly outlined upon the scaffolding she spun, upon its margin only, long curled threads, each made by attaching her spinnerets to one point of the margin, then elevating them and attaching them again close to the first point of attachment; thus she made a marginal wall, just sufficiently elevated to be seen with the naked eye. From 10.01 to 10.06 she worked upon this wall. Then the oviposition followed upon the centre of the base from 10.07 to 10.10½. From then until 10.20 she started covering the egg mass with high upliftings of the spinnerets, thus laying down loops of threads, and from 10.20 to 10.24 with brushing movements of the spinnerets. From 10.24 to 10.26½ she occupied herself in biting the cocoon loose. Then she held the cocoon below her and spun upon it until 11.07, when she attached it to her spinnerets.

♀ No. 63 I found at 7.15 P.M., June 7, laying the covering upon the egg mass. She cut the cocoon loose at 7.23, at 7.24 walked about with it attached to her spinnerets, but at 7.26 held it below her again and spun upon it until 7.59. At 8.04 she attached it to her spinnerets again for a couple of minutes, then commenced to spin upon it again.

♀ No. 61 was unsuccessful in her cocooning; at 10.30 P.M., May 11, I found her holding beneath her cephalothorax a misshapen object, bowl-shaped and of a bluish color, evidently a miscarried cocoon; she tried in vain for a long time to spin upon it, and finally dropped it.

Thus the nearly globular cocoon is formed from two separate pieces.

The number of cocoons, and the dates of their making, were as follows:

(1) ♀ No. 33: June 10 (did not hatch as it had not been cut).

(2) ♀ No. 54: May 19, hatched June 7; a second cocoon hatched July 9.

(3) ♀ No. 57: May 12, hatched June 2; July 2, hatched July 19.

(4) ♀ No. 61: May 9, an abnormal cocoon.

(5) ♀ No. 63: June 7, she cut it open but the young never hatched, for she had probably opened it too soon; July 25, an irregularly shaped cocoon, which she destroyed by chewing on the same day.

(6) ♀ No. 65: May 9, hatched June 1; June 10 or 11, hatched July 1.

(7) ♀ No. 58: May 18, hatched June 7; July 12, a very small cocoon which she ate.

(8) ♀ No. 177: June 4, eaten by the mother; June 29, eaten by the mother.

Thus none of my captives made more than two cocoons.

Care of the Young.—The cocoons are carried suspended from the spinnerets, and generally kept well elevated above the ground, the spinnerets being firmly fastened to one of the rounded sides. The mother bites open the cocoon to allow the escape of the young, and unless it is so opened the young cannot get out of it. This biting of the cocoon was observed in several individuals; sometimes it lasts through several days, for only a short time each day; in one case the mother started to cut the cocoon a full week before the young emerged; the following is a typical case: ♀ No. 65 on May 30 was first observed cutting her cocoon. On May 31, at 9.10 P.M., she was cutting it again. The cocoon was held beneath her cephalothorax by the first and third pairs of legs and by the abdomen deflected downward, in such a position that the plane of its largest circumference (its equator) coincided with her median plane. With her chelicera she slowly tore away the thick outer covering along the line of the equator, her palpi aiding, and at the same time her legs slowly rotated the cocoon. This cutting is not a continuous process, but interrupted by frequent short rests as if she were noticing movements of the young. At 10.22 she suspended the cocoon from her spinnerets, and cut again from 10.35 to 10.39. The cut was now very deep, so that through it the spiderlings could be seen moving within the cocoon. Next morning several of the young had crawled out upon her body, and at midday she finally dropped the cocoon, although there were still young within it. Some mothers open their cocoons with a cut extending along almost the whole line of the equator, and once the young are upon her she pays no more attention to the discarded cocoon. It is interesting to note (and this is also the case in the other Lycosids examined by me, perhaps with the exception of *Ocyale*) that the cocoon is always cut open along the line where the cover had previously been cemented to the base of the cocoon; this equatorial line is always a little rougher than the remaining surface of the cocoon, and perhaps this roughness impels her to a further roughening.

The young, on emerging from the cocoon, hang on to the body of the mother for some time before leaving her, and leave in succession, the more vigorous first. ♀ No. 54 carried her young from June 7 to June 13 ; ♀ No. 57 from June 2 to June 9; ♀ No. 58 from June 7 to June 12 ; ♀ No. 65 from June 1 to June 3. Thus in the observed cases the time varies from 2 to 7 days.

Feeding.—As in other Lycosids this species kills the prey by grasping and biting it, and rarely accepts dead insects; and not only sucks the juices of the victim but chews it up. It also drinks water frequently.

Parasites.—Two large individuals of a species of *Mermis* (Nematode) escaped from ♀ No. 152.

Pardosa scita Montg.

This species is much less abundant than *P. nigripalpis*, but still fairly common on some dry, open grounds. It runs and leaps very rapidly, and is difficult to catch. I have made but few observations upon it.

Moult.—As in other Lycosids.

Mating.—Only once was the beginning of a courtship seen. The male touched the female, then waved his palpi in the air in the manner of *P. nigripalpis*, but for only a few seconds, and did not repeat the movement. Afterward whenever he approached her, she would wave her first pair of legs in the air and tap his with hers.

Parasites.—A species of *Mermis*.

Pirata liber Montg.

This is the common local species of the genus, and frequents marshy ground. It dies very quickly from thirst and is with difficulty kept alive in confinement. A number of individuals were watched, but the following were the only observations worth recording.

Mating.—A male placed in the cage of the female touched her, went off, then returning with his first pair of legs outstretched and in tremulous vibration he touched her with them, when she jumped at him. This might have been a courting movement on the part of the male, or else a cautious reconnaissance.

Cocooning.—On June 2, at 1.30 P.M., I found a female had spun a scaffolding of silk threads from the floor to the wall of the cage, and upon it a circular disk of white silk; the latter was evidently the base of the cocoon. I unfortunately placed a drop of water near her on the glass floor of the cage. She then left the cocoon base, spun upon the surface of the water drop, evidently mistaking it for the silken base, and ultimately oviposited upon it. Later she raised and held the egg mass beneath her cephalothorax, holding it there with her palpi, chelicera, third pair of legs, and with her abdomen bent vertically downward, and endeavored to spin upon it in that position. But there was only a thin covering of silk on only one surface of the egg mass, the cocoon came to grief, and she ultimately ate it up. The drop of water had disturbed the regular course of the cocooning. In the state of nature this species carries its round cocoon attached to the spinnerets.

Ocyale undata (Hentz). Pl. IV, fig. 1.

Care for the Young.—This species, as Hentz and Emerton have described, constructs a web-nest for its young in the top of small plants. I kept several females in order to learn this habit more in detail, and the following notes relate to ♀ No. 235, captured June 22.

This spider was caught upon the ground in a wood, laboriously moving along with its large spherical cocoon. Then, and for the first evening after her capture, she held her cocoon beneath her body with the aid of her chelicera, palpi and with her abdomen pressed against it; but unlike other Lycosids, her spinnerets were not attached to it. That night she spun a network of lines in the cage, and next morning was hanging upside down, hanging to the web lines with the claws of her first and fourth pairs of legs, tightly embracing the cocoon with her other legs, her chelicera and her palpi, in the position shown by the sketch. Only once up to the time of hatching did she leave the cocoon hanging in the web, and then in order to clean herself; at all other times she continued to hold it tightly, and refused flies and beetles put in as food. She occasionally climbed about with the cocoon, spinning new lines in the cage, until quite a thick network was made; and on July 9 I found the cocoon, bitten open by the mother, hung high in the web, and numerous newly hatched spiderlings distributed over the web. She spun so many new lines that she herself finally became enmeshed in them, and on July 18 I cleared them away. On the early morning of July 22 she made a second cocoon, when there were no nest lines in the cage; on August 9 she fastened it to the roof of the cage, cut it open with her jaws so that the young emerged, and in the succeeding days built a web-nest around it.

From these few observations we may conclude that the cocoon is made first, that the mother most carefully holds it until the time for hatching, when she cuts it open and then spins the web-nest around it. This method of holding the cocoon, and of guarding the young upon a nest instead of carrying upon her body, is shared by our local *Dolomedes urinator* Hentz, but is different from the usage of the other Lycosid genera. These web-nests are generally found on the top of plants along the sides of wooded streams, and have a decided resemblance to the nests of Lepidopterous larvæ.

Tegenaria derhami Scop.

Individuals observed, males: No. 23, captured May 2, escaped May 22; No. 74, captured May 13, died (from starvation) June 5; No. 80, captured May 14, killed May 27; No. 178, captured June 5, died July 24; No. 218, captured June 19, died about September 1; No 221, captured June 19, died July 8; No. 252, captured June 26, killed (by ♀ No. 25) the same day.

Individuals observed, females: No. 22, captured May 2, died May 21; No. 25, captured May 2, died August 4; No. 75, captured May 13, died August 19; No. 79, captured May 14, died September 1; No. 84, captured May 15, killed May 25; No. 117, captured May 24, died about September 10; No. 118, captured May 24, escaped June 5; No. 219, captured June 19, died in December; No. 220, captured June 19, died the first week of September.

Moulting.—This was seen only once; the moulted skin was split in the horizontal plane as in other spiders.

Mating.—The mode of observation was to put a male upon the web of the female, and the male was in most cases left with her and not removed, since removal would necessitate a breaking of the web. The male is of about the same size and strength as the female, and the two generally live peacefully together. Sometimes the male is the more aggressive and secures all the food placed in the cage, but more generally the female lords it a little over the male. The following are my main observations on the approach of the male and the mode of copulation:

(1) On to the web of ♀ No. 22 I placed ♂ No. 23 on May 3, at 2.41 P.M. They touched each other a few times, then remained motionless facing each other from 2.49 to 3.02. Then she moved toward him and followed him slowly, she finally touched him and he moved away. Then both remained immovable until 4.00, when I removed him. On May 3 I put him in again at 9.15 P.M.; he touched her,

she instantly turned and faced him, their fore-legs almost in contact. They remained in this position until 9.29, he tapping the web a few times with his palpi, while she shook the web vigorously with her left fore-leg for a couple of seconds. At 9.30 he rubbed his palpi vigorously with his fore-legs, then approached and copulated, this act lasting only 5 seconds. Their exact position in the act was not determined. I could only observe that he approached head on with one palpus outstretched, they mutually grasping each other with their first pair of legs, both in their usual position on the upper surface of the web. She then moved away. At 9.35 he walked over her without copulating. At 10.25 she approached and tapped him several times with her left fore-leg, and again at 11.02. I watched them continuously up to 12.27, then left him with her. Up to May 21, when she died (he securing most of the food given them), I watched them many times, saw him on some occasions approaching her with shaking palpi, but observed no further copulation.

(2) To ♀ No. 25, after she had made 3 cocoons, I introduced ♂ No. 225; she chased and killed him.

(3) ♀ No. 79 had made 3 cocoons, when ♂ No. 178 was introduced on June 19, at 9.15 P.M. He moved toward her very slowly, a step of a centimeter each time, slowly and cautiously tapping the web with his palpi; he took about 9 minutes to cross a distance of 2 inches, and then when he had almost reached her, she rushed at him and drove him away. At 9.35 he again approached cautiously, and at 9.50 rushed at her, but she repelled him. At 9.57 he advanced again, at 10.10 making a quick rush at her and almost succeeding in inserting an extended palpus in her epigynum, but she escaped from him. No copulation was seen up to 11.25.

(4) ♀ No. 117 made her first cocoon on June 10. On June 19, at 9.40, ♂ No. 221 was placed on her web. At first she chased him about, then both became quiet. At 10.01 he quickly ran at her, and copulated with his right palpus from 10.02 to 10.03, for ten minutes after which she chased him about the cage. The copulatory position was the same as that of ♀ No. 75 × ♂ No. 218.

(5) ♀ No. 75, after making 2 cocoons, mated with ♂ No. 218 on June 19. He was introduced at 9.08 P.M., and shortly after she chased him. At 10.00 he made a sudden move toward her and succeeded in copulation; he inserted his right palpus into her epigynum for 1 minute, his left for 15 seconds, his right again for a minute and a half. Position: the male braced himself firmly on all legs upon the web, and reached his palpus straight out before him and pressed it into the

epigynum with considerable energy; the female faced him also on the upper surface of the web (just within the funnel), lying partly on one side with her legs drawn up, but not closely, to the sides of her body. During the act the male pushed the female backward by his force. When the palpus was inserted there was seen a large dilated sac evaginated from the palpal organ. The female then ran off, and the male proceeded to the process of sperm-induction.

In these copulations the male accordingly first approaches slowly, the female also sometimes making advances on her part, and concludes with a rush at the female, and if he is quicker than she he succeeds in inserting his palpus. The fact that females copulate after cocooning makes it appear probable that a copulation may precede the making of each cocoon.

Sperm-induction.—♂ No. 218 was watched during this act, which occurred immediately after his copulation with ♀ No. 75 (concluded at 10.03 P.M.). He first spun across an area of nearly a square inch on the upper surface of the web, then limited himself to a small area just at the entrance of the tunnel of the web. Here, by very rapid brushing of the spinnerets from side to side, he constructed a delicate silk sheeting placed at an acute angle to the surface of the nearly horizontal web, the posterior and lateral edges of this sheeting attached to the web, but its anterior edge unattached and elevated like an arch. From side to side this sheeting was not quite so long as the length of his body, and half this distance from before backward. He then stood over it, so that the ventral surface of his abdomen almost touched the superior surface of the sheeting, his cephalothorax above the anterior (free) edge of it, and his spinnerets at its posterior edge. At 10.21½ P.M. he moved his abdomen slightly forward, discharged from his genital aperture a minute drop of sperm upon the superior surface of the sheeting at its free edge, and from that moment until 10.28 he was engaged in taking this sperm into his palpal organs. This he did by pressing the ventral (posterior) surface of each palpal organ on the under surface of the sheeting, just at the point where the drop of sperm had been placed on its upper surface; one palpus he held thus, with occasional shaking, for 10 to 15 seconds, then the other, until the whole of the drop was inducted; and each palpus when not so busied he held in front of his cephalothorax and shook it in the air, as if to force the semen deeper into the organ. From 10.27 until 10.34, just after the completion of this process, he remained in the same position, but quietly and with no further discharge of semen upon the sheeting. Then he left the sheeting, worked his palpi a short while with his chelicera, then remained quiet until 11.10 when I ceased the observations. The spirit is always willing to watch longer, but continuous observation with a hand lens, and the necessity of keeping quiet in a cramped position for fear of startling the object, becomes trying to the flesh.

A curious act which I observed ♂ No. 23 to do I cannot explain, but it may possibly have some connection with the mating. On May 3 he was upon the web of ♀ No. 22. At 9.50 P.M., after his copulation with her (described above), he commenced to tear a hole in the horizontal portion of her web, tearing with his palpi and putting the torn shreds in his jaws. He thus made an oblong rectangular hole of about the length of his body, and as he continued to tear the portion just in front of him, he swung his spinnerets over the posterior part of the hole, and so spun it over with very fine transverse lines. This act lasted until 10.04, and only about one-quarter of the hole in the web had been mended over. Though I watched him closely up to 12.27 A.M., he did not return to this hole.

Cocooning.—This was observed several times, and was as follows:

♀ No. 79 was observed at 8.00 A.M., June 19, spinning over a circular area (of greater diameter than her own length) on the vertical glass wall just above the edge of the web. She ceased until 8.09, owing to a jar to the cage, then commenced again. Very regularly and actively, without interruption, she spun up to 8.23, placing her feet at the periphery of the silken disk ("base" of the cocoon), and revolving her body over it, turning sometimes from right to left and sometimes in the reverse direction, all the while beating the tips of her palpi upon the disk. During the earlier part of the process the outstretched spinnerets were brushed from side to side; but in the latter part she lifted the abdomen high after each application, thus pulling out long threads which she fastened close to their first point of attachment, so that the inmost (most lately made) part of the disk was made of curled loops, and so was of very soft consistency. Thus the base of the cocoon, somewhat thickest in the centre, was formed. At 8.23 she stood quietly over this base, then oviposited upon it, the oviposition lasting a little more than one minute. From her genital aperture exuded a large clear drop of viscid fluid and fell upon the centre of the base, its upper surface still connected with her genital aperture, and at the same time the yellowish ova fell into and were enveloped by this drop. Then she immediately began spinning the cover of the cocoon over the egg mass. From 8.24⅗ to 8.35 she spun a loose covering of silken loops by elevating the spinnerets after each application (just as in the making of the base), and from 8.35 to 8.44 she spun a denser covering by brushing the spinnerets from side to side. Finally she alternated the spinning upon the cocoon itself, with spinning attachment lines from it to web.

♀ No. 25 made her first cocoon on the horizontal surface of her web, apparently not spinning a special base.

♀ No. 75 made her second cocoon upon the surface of the web, and after spinning a discoidal base oviposited upon it at 7.41 A.M.; she occupied the time from 7.42 to 8.00 in spinning the cover.

♀ No. 220 spun her cocoon in the same manner as did No. 79.

One female, after making her cocoon at the angle of the wall and floor of the cage, spun over it several thin, concentric, arched lamellæ of silk, evidently a protection. In a few cases the female attaches foreign particles, as the remains of insects, to the surface of the cocoons, but this was not done with the majority of the cocoons. The cocoons, even those of the same spider, are placed in most diverse positions, some horizontally and some vertically, some upon the web and some away from it.

The number of cocoons made and the dates of construction were as follows:

(1) ♀ No. 25: May 31 (hatched June 9); May 29; June 10 or 11 (hatched July 5); June 20 (hatched July 16); July 2 (did not hatch); July 9 (hatched July 31); July 21 (not all the eggs hatched); August 1 (hatched). A total of 8 cocoons made by an unusually small female.

(2) ♀ No. 75: May 23 (hatched June 14); June 7 (destroyed by the mother); July 5 (hatched July 30); July 17 (hatched August 2). A total of 5 cocoons.

(3) ♀ No. 79: May 24 (hatched June 19); June 7 (hatched July 5); June 19 (hatched July 12); June 29 (hatched July 19); July 7 (did not hatch); July 17 (hatched August 9); August 1 (hatched); August 21 (hatched). A total of 8 cocoons.

(4) ♀ No. 117: June 10 (hatched July 6); June 26 (none of the ova developed); July 3 (hatched July 23); July 12 (hatched July 29); July 27 (hatched August 20); August 8 (hatched); August 28 (hatched September 29). A total of 7 cocoons.

(5) ♀ No. 118: May 31 (hatched June 5).

(6) ♀ No. 219: July 4 (hatched July 24); July 28 (hatched August 21); August 21 (hatched). A total of 3 cocoons.

(7) ♀ No. 220: June 29 (hatched July 27); July 16 (hatched August 2); July 30 (hatched August 22); August 21 (hatched). A total of 4 cocoons.

The differences in the time of hatching are probably due as much to differences in the thickness of the cocoons as to any such factor as temperature.

Care of the Young.—I have seen no evidences that the mother guards in any way either her cocoons or her young. The young make their own way out of the cocoon, making an opening or openings at the margin where the cover is joined to the base; that the mother does not tear the cocoon open for them is proved by the cases where the young emerge at a point that is inaccessible to the mother.

Feeding.—This is rather a timid species, the great protection afforded by the tubular portion of the web compensating for want of strength, and they rarely attack prey as large as themselves, and usually avoid much smaller spiders. The prey is killed by biting, and after being sucked dry is usually left hanging in the web. The males especially are frequently eager for water.

Agalena nævia Walck. Pl. IV, fig. 4.

Individuals observed, males: No. 72, captured May 11, moulted May 24, June 7, July 3, July 28, died September 30 (starvation); No. 303, captured July 9, moulted August 2, killed by ♀ No. 243, August 20.

Individuals observed, females: No. 73, captured May 11, moulted May 13, 25, June 7, 29, July 13, August 5, still living; No. 206, captured June 16, moulted June 29, July 27, died in December; No. 243, captured June 22, moulted July 3, July 28, died in November.

Moult.—The first moult of ♀ No. 73 commenced at 11.08 P.M., she hanging with her spinnerets and feet attached to the roof of the cage. The old skin split into a dorsal and a ventral piece, separated by a horizontal break along the sides of the abdomen, along the sides of the cephalothorax above the legs and below the eyes. She slowly fell out of the split exuvia, with the help of slight convulsive movements of the body and legs. Her legs were completely freed at 11.15, and at 11.23 she hung head down attached to the exuvia only by the spinnerets. At 11.39 she climbed into the web. The new skin is at first much lighter than it becomes on exposure to the air.

Mating.—The two cases seen were these:

(1) ♀ No. 73. ♂ No. 72 was placed upon her web on August 21, at 10.20 A.M. Both were immovable up to 12.00, when I left them. On my return at 12.40 his fore-legs were touching hers. At 12.47 he shook his body. At 1.20 she flexed her legs close to her sides, he being then upon the web half an inch above her. At 1.26 he seized her from above, his head pointing toward her spinnerets, and tapped her abdomen several times with his first pair of legs, she motionless. At 1.36 he left her; she remained inert until 1.46, then moved somewhat,

when he quickly turned and faced her and she became again motionless with her legs flexed closely. At 2.06 he pulled her toward and beneath him, his head facing her spinnerets and just above the pedicel of her abdomen; at 2.08 turned her partially on her side, then applied his left palpus from 2.08 until about 5.00, then applied his right palpus on her other side from 5.00 until 9.40; the number of insertions of each palpus was not noted. At 9.40 he stood over her. At 9.46 she moved slightly for the first time, when he embraced her again and tapped her abdomen rapidly with his fore-legs, got her again into copulatory attitude and inserted his left palpus from 9.50½ to 9.54. He then withdrew this palpus and cleaned it vigorously with his chelicera until 9.58, when he left her. She quickly rose and followed him, but he escaped.

(2) ♀ No. 243. ♂ No. 303 was dropped upon her web on August 19, at 3.14 P.M. At 3.34 he placed his first pair of legs upon hers, while he was higher in the web than she. At 3.37 she turned away, then faced him again, and at 3.40 he moved still nearer. At 3.46 he suddenly grasped her with his legs, and, she flexing her legs to her sides and becoming motionless, he carried her an inch away from the place. At 3.49 he left her still lying inert and walked about, evidently seeking a place on the web favorable for copulation, returning to and standing over her half a minute later. At 3.51½ he seized two of her legs with his chelicera, carried her about, then dropped her. At 3.54 she turned around. At 3.59 he seized her again, placing himself over her with his head directed obliquely toward her spinnerets, she lying partially on one side with her legs flexed, and commenced the copulation with his left palpus. The length of time of each insertion of this palpus was as follows: 3.59–4.19½, 4.20–4.30, 4.31–4.37½, 4.39–4.46½, 4.47–4.56, 4.57–5.03, 5.03¾–5.08½, 5.09–5.14, 5.15–5.22, 5.23–5.31, 5.31¾–5.41½, 5.42½–5.49½, 5.50–5.55, 5.56–6.01, 6.01¾–6.09, 6.09½–6.14, 6.14¾–6.24, 6.24½–6.28, 6.29–6.36, 6.36½–6.56½, 6.57–7.10½, 7.11–7.21, 7.22–7.30½, 7.31–7.40½, 7.41½–7.50½, 7.51–7.58½, 7.59¼–8.06½, 8.07–8.16, 8.17–8.36½, 8.38–8.39, 8.40–8.54. He inserted the palpus each time by extending it downward along the left side of her abdomen to her epigynum, and inserting the spirally wound process of the palpal organ for its whole length; when inserted, a large sac connected with the ventro-median side of the palpal organ swelled up. The palpus was withdrawn after this sac had collapsed, and the palpal organ drawn through the chelicera before the next insertion. At 8.55 the male changed his position upon her, so as to bring his long axis parallel to hers, lifted her 1 cm. backward, then stood quietly over her. At

8.58 he brought his head obliquely over her right side, then applied the right palpus, in the same manner as he had the left, as follows: 8.58½–8.59½, 9.00–9.12, 9.13–9.19, 9.19½–9.24, 9.25–9.30, 9.30¾–9.34½, 9.35–9.39, 9.40–9.45, 9.46–9.49½, 9.50–9.56, 9.56½–10.02, 10.02½–10.06, 10.06⅓–10.16, 10.16½–10.23, 10.23½–10.29½, 10.30½–10.39½, 10.40–10.45, 10.45½–10.55, 10.56–11.18, 11.18½–11.31, 11.32–11.46⅓, 11.47–11.59. Then for very weariness I ceased watching and left them in copula, and next morning found the female eating the male. The female was immovable throughout the whole act, her sternum with its ventral surface downward, but her abdomen twisted on its long axis so as to flex the epigynum up to meet the palpus of the male. His right palpus was used upon her right side, his left palpus upon her left side.

The copulation lasted in the first of these cases for 7 hours and 47 minutes; in the second case it was watched for exactly eight hours, but lasted longer. In both cases the approach and behavior of the males was alike, and both used the left palpus first. There was nothing in the behavior of the males to indicate a courtship; there was simply a cautious approach of the male, and after he had found no sign of hostility on the part of the female he quickly seized her, and she was absolutely submissive in his grasp. When he first grasps her he taps her abdomen with his first pair of legs, perhaps an act of subjugation.

Not one of the females have made cocoons up to the time of this writing (October 5).

Dictyna volupis Keys. Pl. V, fig. 6.

Numbers of individuals of this species were collected on May 26 upon vines of *Ampelopsis* and English ivy growing upon the walls of my old homestead, near West Chester, Pa. They had constructed their webs upon the upper surface of the leaves of these plants, and upon most of the webs a male and female were found together, and a number of these were found then in copulation. This species is easily kept in captivity, and on account of their small size I kept them in test-tubes with the mouth loosely plugged with cotton, placing a male and female together in each tube, when they made the webs conjointly; males and females caught together were kept together.

Individuals observed, males: No. 130, caught on web of ♀ No. 131, died June 15; No. 132, caught on web of ♀ No. 132, died June 24; No. 134, caught on web of ♀ No. 135, died in June; No. 136, caught on web of ♀ No. 137, died June 16; No. 138, caught on web of ♀ No. 139, died June 3; No. 140, caught on web of ♀ No. 141, died June 18; No. 142, caught on web of ♀ No. 143, died July 2; No. 144, caught on web of ♀ No. 145, died June 3; No. 146, caught on web of ♀ No. 147, died in June; No. 148, caught on web of ♀ No. 149, died June 7.

Individuals observed, females: No. 131, escaped June 14; No. 133, escaped

July 2; No. 135, died early in September; No. 137, died early in September; No. 139, escaped June 3; No. 141, died about September 1; No. 143, died August 6; No. 145, still living; No. 147, died about September 28; No. 149, died in September.

Mating.—The following were the observed cases worthy of note:

(1) ♀ No. 133. ♂ No. 132 was introduced at 12.30 P.M., May 27. Most of the time he spent in spinning upon the web, but sometimes approached and touched her, when she either moved away or else shook her legs tremulously. At 3.40 I was obliged to leave, and on my return at 4.33 found them in copula against the bottom of the test-tube. She lay upon her left side with her legs flexed close to her body, her abdomen and cephalothorax in one line. He lay upon his right side with his face pressed against the ventral surface of her cephalothorax and his ventral surface turned toward hers, but not parallel with it, the axes of their abdomens diverging at an angle of more than 45°; his first two pairs of legs embraced hers closely, his posterior pairs were directed backward and braced against the web. This male had lost his right palpus; his left he extended backward along the ventral surface of her abdomen so as to hold the palpal organ inserted in her epigynum. This copulation lasted without interruption up to 5.32. Then after she had made two cocoons, on June 4 and 9 respectively, the same male was found in copulation again at 12.59, continuing so up to 1.48, when he left her, and though he returned several times she met him with open jaws, except once when she approached him with closed jaws, shaking her flexed first pair of legs. Then he proceeded to charge his palpus with sperm.

(2) ♀ No. 135. ♂ No. 134 was found at 7.35 P.M., May 27, in copulation; the embrace was as in the preceding case, except that their bodies were directed upward. Only the right palpus was used, and that was kept continuously inserted; a large evaginated sac connected with this palpal organ dilated and contracted 10–11 times a minute, each dilation of it accompanied by a slight jerk of his abdomen. He suddenly left her at 8.09, worked his palpi through his jaws, shortly after fed upon a gnat, and no further copulation was observed up to 10.20. On June 13, after she had made three cocoons, they were seen again in copulatory attitude, but his palpi were not inserted.

(3) ♀ No. 141. ♂ No. 140 was embracing her at 2.00 P.M., May 31, but his palpi, though pressed against her abdomen, were not inserted. The right palpus was inserted continuously from 2.15 to 3.06. He then moved a few millimeters away, and on approaching her again she rushed at him with opened jaws and chased him the length of the

test-tube. No further copulation was observed up to 4.20. On June 5, at 12.55 P.M., she having made no cocoon in the meantime, they were again copulating, he using his left palpus continuously up to 2.10, then his right from 2.10 to 3.13, after which he ran to the opposite end of the test-tube and cleaned his palpi with his chelicera.

(4) ♀No. 147. May 26, at 2.00 P.M., ♂No. 146 approached and seized her, then inserted his left palpus continuously from 2.04 to 3.02, then at 3.02 his right and kept it inserted up to 4.20, when I was obliged to stop observations; they were separated on my return at 5.25.

(5) ♀No. 149. At 8.14 P.M., I saw ♂No. 148 come face to face with her, then, each of them tapping upon the web with the first two pairs of legs, they moved backward and forward slowly. This lasted only two minutes, when they both became quiet half an inch apart; it was repeated again for a short period at 8.54. On June 1 they were seen in copulation at 4.52 P.M., he inserting his left palpus, and again on June 4, at 11.35 A.M., continuing up to 11.50, he using his left palpus, and afterward he proceeded to the sperm-induction.

In this species the male is shaped quite different from the female, and is a little larger (an unusual condition among spiders). There is no true courtship on the part of the male, for his tapping upon the web with his fore-legs is an act which the female also does. More than one copulation may precede the making of a cocoon; and copulation may follow cocooning. The longest time a pair was seen in continuous copulation was 2 hours and 18 minutes, the left palpus here being employed for 1 hour and 15 minutes, then the right for 1 hour and 3 minutes.

Sperm-induction.—This was seen twice:

(1) ♂No. 132 terminated his second copulation with ♀No. 133 at 1.35 P.M. After that I watched him continuously with a lens. From 2.00 to 2.19 he alternated spinning upon various portions of the web with cleaning his palpi with his chelicera. At 2.20 he commenced spinning over a small area, the diameter of which was not larger than the length of his abdomen, and ceased at 2.22. Half a minute later he bent his abdomen downward and discharged from his genital aperture a minute drop of sperm, which appeared to adhere to the delicate web beneath him, and at the same moment reached his left palpus (his right was missing) downward and backward beneath his cephalothorax and took this drop into the palpal organ. He then remained quiet up to 1.42, when I stopped observations, occasionally shaking his palpus in the air, but discharging no more sperm.

(2) ♂ No. 148, on June 4, ceased his copulation with ♀ No. 149 at 11.50 A.M. About 4 minutes afterward he started spinning on the glass wall, not using his calamistra, and made a close but scarcely visible silk sheeting at one place. This continued up to 12.05 P.M., when he stood over it, shaking his palpi and rubbing them against his chelicera. At 12.10 a minute whitish globule of sperm fell from his genital aperture upon the silk sheeting, rolled forward upon it (*i.e.*, toward his head), and was immediately taken into one of his palpal organs, and that palpus was then shaken repeatedly many times. After that he remained in the same position, flexing his palpi and pressing them against the silk sheeting. But there was no further discharge of semen, though I watched him continuously with a lens. He spun again in another place from 12.20 to 12.27, then went off to feed upon a fly.

The peculiarity of the sperm-induction in this species is its rapidity, and the fact that the palpi are not placed beneath the silk layer made to catch the drop of sperm.

Cocooning.—This process was not seen, most of the cocoons having been made in the early morning. Only the conclusion of it was noticed in a couple of cases, *i.e.*, the finishing of the cover of the cocoon; silk was applied that had been drawn out by the calamistra from the cribrellum. And female No. 131 was seen standing over a flat circular disk of silk one day at 12.00 P.M., and sometime before the next day she oviposited upon it and spun another disk as a cover; this observation shows that this species, as other spiders, makes her cocoon of a base and a cover.

The number of cocoons made, and their dates, were as follows:

(1) ♀ No. 131: June 4, June 7. 2 cocoons.

(2) ♀ No. 133: June 4 (hatched June 23); June 9; June 17; June 20. 4 cocoons.

(3) ♀ No. 135: June 8 (hatched June 22); June 9; June 13; July 5; July 8; July 9; July 11; July 15; July 31. 9 cocoons.

(4) ♀ No. 137: June 10 or 11 (hatched June 24); July 3; August 3; August 19. 4 cocoons.

(5) ♀ No. 141: July 3; July 7; July 13; July 26. 4 cocoons.

(6) ♀ No. 143: July 4; July 24. 2 cocoons.

(7) ♀ No. 145: July 10; July 15; July 24; July 30; August 11. 5 cocoons.

(8) ♀ No. 147: June 4 (hatched June 18); June 6 or 7; June 17 (hatched July 3); June 22; July 4; July 18; July 27. 7 cocoons.

(9) ♀ No. 149: June 14 (hatched June 29); July 16; July 19; July 23; July 29; August 1. 6 cocoons.

The quick succession of these cocoons will be noticed, sometimes cocoons being made upon consecutive days. This is because only a few eggs (perhaps never more than 12 or 15) are laid in any one cocoon. The base of the cocoon is a flat disk, generally broader than the more or less arched cover; the cocoons are pure white. In the test-tubes most of them were placed against the glass, others built upon the web; sometimes they were arranged in rows, one placed upon another.

Care of the Young.—The mother appears not to remain by her cocoons nor to guard them in any way. The young make their own way out of the cocoons, emerging at one point between the base and the cover.

Feeding.—Relatively to its size this species is the most forward in attack, attacking large insects, such as blue-bottle flies, which many larger spiders flee from. It evidently trusts to the great strength of the web, in which large insects become helplessly entangled. The little spider rushes immediately at the entangled victim, seizes hold of it with his jaws without spinning upon it, and keeps his hold though violently shaken by the prey.

Theridium tepidariorum C. Koch. Pl. IV, fig. 2.

Individuals observed, males: No. 7, captured April 29, killed May 19; No. 8, captured April 29, moulted the same day, escaped the same night; No. 13, captured May 1, escaped May 3; No. 19, captured; May 2, killed May 16; No. 20, captured May 2, killed by ♀ No. 17 May 18; No. 71, captured May 8, killed May 23; No. 77, captured May 13, moulted May 15, died (of starvation probably) June 3; No. 81, captured May 14, killed May 18; No. 115, captured May 24, killed next day; No. 116, captured May 24, killed next day; No. 123, captured May 26, died June 7; No. 125, captured May 26, died June 11; No. 126, captured May 26; No. 127, captured May 26, died June 6; No. 155, captured May 30, died June 29; No. 217, captured June 19, died June 29; No. 254, captured June 26, killed (by ♀ No. 253) July 10; No. 319, captured July 14, died August 6.

Individuals observed, females: No. 6, captured April 29, died June 19; No. 16, captured April 29, died about September 1; No. 17, captured April 29, moulted May 9, killed May 30; No. 18, captured May 2, died (apparently starvation) June 2; No. 26, captured May 2, killed May 8; No. 76, captured May 13, died (starvation) June 3; No. 124, captured (on the same web with ♂ No. 123) May 26, died July 3; No. 129, captured May 26, died July 29; No. 154, captured May 30, died about September 1; No. 156, captured May 30, died July 23; No. 202, captured June 11, died July 29; No. 253, captured June 26, died about September 1.

Moulting.—This was observed in one ♂ only; the process lasted about half an hour, the spider slowly falling out of its old skin, and the legs were quite colorless immediately after the moult.

Mating.—The method of observation was to keep a female in a cage until she had made a web there, then to drop a ♂, handling him as gently as possible, upon her web.

The introductory steps of the mating are as often made by the female as by the male, and she often shows quite an insatiable eagerness, even sometimes leaving food to approach the male. As soon as the male commences to move upon her web she recognizes him as a male of her own species, and, when she is eager, commences immediately to signal to him, both spiders being on the lower surface of the web and upside down (the usual position). The female hangs to the web with the third and fourth pairs of legs, and shakes the longer second and first pairs vigorously and spasmodically in the air (when those legs are not attached to web lines), otherwise with them she shakes web lines to which they are hooked. This "signalling" is a sign of eagerness on the part of the female, and so far as I have observed she makes it at no other time than when she is eager and notices the approach of a male of her own species. There are individual differences in the mode of signalling, as well as differences in accord with the degree of eagerness of the female; sometimes a female signals without moving from her original position, sometimes with the signalling she moves by short steps toward the male. When she is not eager she either remains motionless, or else rushes hostilely toward the male as at an object of prey; in both cases the male makes no advances, and when she is markedly aggressive he escapes by dropping from the web. The whole attitude of the male is that of combined timidity and eagerness; he is much smaller than the female and upon a foreign web, and usually acts with great caution. Very frequently he will climb about the web for a greater or longer period, the female all the while signaling, before he approaches her; often he approaches and touches her several times and each time rapidly withdraws again; more rarely, the male responds quickly to the signalling of the female and copulates within a minute of time. Sometimes the male, while moving about on the web, on coming across a break in it, will pause to mend the break before approaching the female. The male shows his eagerness by a spasmodic jerking of his abdomen. He tests the eagerness of the female, and finds her position on the web, by grasping with the claws of his first pair of feet the web lines that she is shaking by her signalling, and by drawing these web lines taut he feels her movements all the more distinctly; he approaches gradually nearer her, guided by her signalling. and finally makes a short rush toward her.

In this species the courtship, if the expression of eagerness may be so called, comes evidently much more from the female than from the male; and that the male is not able to satisfy the female is shown by the fact that the latter continues her signalling for some time after the copulation. The mode of sexual recognition is entirely by touch, by the tension of the web lines.

The copulation I have observed many times. Both individuals being on the lower surface of the web (in small cages the female spinning a horizontal web about half-way between the floor and the roof), on the close approach of the male the female hangs to the web by the claws of her third and fourth pairs of legs, her other legs hanging unattached, so that her cephalothorax lies beneath her abdomen. The male places himself parallel to her, his ventral surface opposite hers, his cephalothorax also above her abdomen, his position in the web higher so that his head is opposite her epigynum, embracing her closely with his second and third, sometimes also with the fourth pair of legs, while his long first pair of legs beat about in the air. His palpi are applied to her epigynum generally both at the same time; sometimes only one palpus is employed during one copulation. The length of time of the application of the palpi is rarely 15 seconds, usually less than 10 seconds, and all this time the female remains perfectly motionless. The copulation completed, the male hurries away, or else falls down out of the web and remains for some seconds motionless, his energies evidently spent. After copulating he cleans his palpi with his jaws. Sometimes the male has difficulty in inserting his palpi into the epigynal orifices, and tries ineffectively many times while the female remains motionless. The copulation is so soon over that I have not been able to determine the exact action of the palpi during it.

This species copulates very frequently, and there are several matings preceding the making of each cocoon. The female appears always eager except in the time of full pregnancy, and may mate with numerous males, as the following data show:

(1) ♀ No. 6 copulated with ♂ No. 7 at 7.53 P.M., April 29, and this ♂ showing no more desire was removed at 9.25. Put him with her April 30, copulation at 1.43 P.M. Again on April 30, at 11.12 P.M. Again at 7.44 P.M., April 30, half a minute after he was put in. On May 3 I put him with her again for two hours, but no copulation. On May 4, copulation at 9.20 A.M., five minutes after he was put in; and again at 8.39 P.M. and 8.43 P.M. May 5, put him in again at 7.59 P.M., copulation within half a minute, and a second one at 8.01. On May 6, when I put him upon her web, she acted hostilely. May 8.

copulation at 5.24 P.M., half a minute after his introduction. On May 11 she was hostile to him, as also on May 13; at this date she was very large with eggs, which she laid May 19. May 24 I introduced ♂ No. 115 at 4.51 P.M., he copulated immediately; he was removed at 4.05, and ♂ No. 116 placed with her, copulating at 4.07½ and 4.08. May 25 I put in ♂ No. 116 from 10.10 to 11.00 A.M., but he avoided her, though she made amatory signals; and ♂ No. 115 behaved similarly on the evening of the same day. May 27, ♂ No. 125 copulated at 2.50 and 2.53; and the same ♂ at 8.43 and 8.45 P.M., May 28. On May 28 put in ♂ No. 128, copulation at 8.57½ and 8.58 P.M. May 29, put in ♂ No. 125, copulations at 6.00, 6.01, 6.02 P.M.; and he copulated with her on June 1, at 5.30½ and 5.31 P.M. June 2, ♂ No. 126 was placed in her cage, but he showed no eagerness and was removed at 9.25 P.M.; then ♂ No. 125 was put in, and copulation followed at 9.32½. June 30, put in ♂ No. 125, but no copulation ensued, although she was eager. June 17, put in ♂ No. 215 at 11.00 A.M., and two copulations followed within 3 minutes. (A total of 27 observed copulations.)

(2) ♀ No. 16 copulated with ♂ No. 13 at 7.55, 7.56, 7.56½, 7.58, 8.00 and 8.04½ P.M., on April 29, the ♂ after each copulation moving half an inch away from her and drawing his palpi through his jaws. May 4 I introduced ♂ No. 19 from 7.35 to 9.40 P.M., but there was no copulation. On May 5, ♂ No. 19 copulated at 8.14, 8.18 and 8.19 P.M.; and the next day at 7.39 P.M., a minute after his introduction. On May 8 ♂ No. 19 copulated with her at 5.33 and 5.37 P.M.; and on May 13 at 4.22 and 4.23 P.M. On May 14 I introduced ♂ No. 7, on May 15 ♂ No. 19, on May 16 ♂ No. 19, but she was hostile on each occasion (she oviposited May 25). On May 25, at 10.10 A.M., just after the completion of the cocoon, ♂ No. 115 was introduced; she first rushed at him, then held herself in copulating attitude, then became again hostile. May 27 I introduced ♂ No. 127 at 3.10 P.M., she rushed at him and started to enshroud him, but when he touched her with his legs she ceased, and copulation followed at 3.11 and 3.12. May 28, ♂ No. 127 was put in at 9.08 P.M., copulations followed at 9.09, 9.09½, 9.10. May 29, ♂ No. 127 copulated at 5.27 P.M.; but when ♂ No. 128 was put in his place at 5.30, she chased him hostilely. June 1 I put in ♂ No. 127, but she acted hostilely (perhaps from hunger this time, as she had not been fed for three days). June 2 I introduced ♂ No. 127 while she was feeding, and she chased him from the web. June 7, ♂ No. 182 was introduced, but though she signalled eagerly he did not mate. June 15 (a cocoon was built by her the preceding day) I introduced ♂ No. 182, copulation ensued at 7.25 and 7.27 P.M. (A total of 22 observed copulations.)

(3) ♀ No. 18 was put into the cage of ♂ No. 8 on May 2, but she chased him; then ♂ No. 19 was introduced and copulated with her at 11.27, 11.29, 11.29½ and 11.31 A.M. Two Theridiids of a smaller species were put in at 12.00 M., so that five spiders were now together. ♀ No. 18 sometimes would make amatory advances to ♂ No. 8, but he (evidently not mature) fled from her. Several times she came into contact with ♂ No. 19, but after a few excited advances he left her each time. She always acted hostilely to the individuals of the smaller species. She copulated with ♂ No. 19 at 12.42; this ♂ later made a rush at the smaller ♂ No. 8. The latter subsequently escaped, and I removed ♂ No. 19 on May 4. On May 8 a freshly caught large ♂ was introduced, but she seemed frightened by him. On May 9 she copulated with ♂ No. 71 at 7.55 P.M.; he was left in her cage until May 23, and copulations were noticed at 9.15 P.M., May 13, and 9.15 P.M., May 15. (A total of 8 copulations observed.)

(4) ♀ No. 76. ♂ No. 77 was introduced on May 13, but she remained immovable, and was hostile to him next day, as she was to ♂ No. 85 on May 15, and to ♂ No. 77 on May 16. May 18, ♂ No. 77 copulated at 6.59 and 6.59½ P.M. (Only 2 copulations.)

(5) ♀ No. 124 copulated with ♂ No. 123 on May 27, at 2.17, 2.22, 2.27 P.M., besides some unsuccessful attempts. The same ♂ made several unsuccessful attempts on May 28, and one successful one. May 29 I introduced him while she was feeding, she left her prey and signalled vigorously, copulation at 5.49 P.M. May 30, copulations with the same ♂ at 4.44 and 4.49 P.M.; and at 4.55 P.M. ♂ No. 155 was introduced, but he would not answer her amatory signals. On June 1 ♂ No. 123 made protracted but unsuccessful attempts to copulate at 5.43, 5.46, 5.47 and 5.47½ P.M. June 2 she copulated with ♂ No. 128 at 10.28½, 10.29 and 10.32 P.M. June 8 I put in ♂ No. 128 again at 1.36 P.M., while she was eating a beetle; she signalled immediately while remaining close to the beetle, he went toward her and mistakenly tried to copulate with the enshrouded beetle, but ultimately copulated with her at 1.40 and 1.42. June 12 I put in ♂ No. 128 again, copulations followed at 8.59 and 9.16 P.M.; I left them together, and next morning found she had eaten him. (A total of 23 copulations observed, of which a number were unsuccessful.)

(6) ♀ No. 129 copulated with ♂ No. 123 at 8.31 P.M., May 28; later he attempted to insert his palpi but in vain, she then became aggressive. June 2 she copulated with ♂ No. 155 at 8.37 and 8.43 P.M. June 7, with ♂ No. 155, at 8.24 P.M., half a minute after his introduction. June 15, with the same ♂, at 7.23 P.M. (A total of 5 observed copulations.)

(7) ♀ No. 156 copulated with ♂ No. 123 at 12.10, 12.12, 12.12½, 12.13 P.M., June 3. June 19, three times with ♂ No. 217. July 15, at 3.30 P.M., with ♂ No. 319. (A total of 9 observed copulations.)

These observations show that while the copulations are of brief duration, generally less than 10 seconds, they are frequently repeated. The number must be larger in natural conditions than my figures show for caged individuals, since in order to count the number I was obliged to remove the males during those periods when I could not watch them. Even when there are one or more cocoons in her web the female mates as freely as before oviposition, and their presence does not in any way seem to retard her mating impulses.

Sperm-induction.—The following was the only case observed. ♂ No. 319, after copulating with ♀ No. 156 at 3.30 P.M. on July 15, was watched carefully with the hope of seeing this process. He left the female and went to a corner where he remained quiet, hanging with the ventral surface uppermost and the cephalothorax a little lower than the abdomen. At 4.35 P.M. he flexed his abdomen slightly on its pedicel so as to elevate its apex, deposited from his genital aperture a small drop of sperm upon a line of the web, then applied the palpal organs alternately to this drop. This process continued until 4.39 P.M., when he was driven away from the place by the approach of the female. The droplet of sperm had been only slightly diminished in amount, so that probably the induction into the palpal organs takes a much larger time. I watched him for half an hour more; for a while he shook his palpi slightly in the air, but ceased this action and did not emit any more sperm.

Cocooning.—The brown ovoid or subglobular cocoons are very familiar objects in barns and cellars where this species is most frequently found. In captivity they make their cocoons usually in the early morning, completing them before 8.30 A.M., in one case as late as 10.00 A.M.

The process is as follows: ♀ No. 16 was observed commencing her first cocoon at 8.15 A.M., May 25. She was making a fluffy ball of loosely curled white silk, barely a third the diameter of the finished cocoon, suspended by a thread from the roof of the cage. She worked by hanging in the web with her first pair of legs, using the legs of the fourth pair in alternate action to pull out from her spinnerets and apply to the silken mass the white thread, and occasionally helping with the third pair of legs. At 8.23½ she placed her epigynum close to the lower surface of the silken ball, and there issued from her genital aperture a large, yellowish, viscid drop of fluid in which ova could be indistinctly seen; this drop was not very transparent, so that I could not determine whether the drop was first exuded and then the ova rolled into it, or whether they were discharged together, but appearances were more in favor of the last supposition. This drop was very viscid and of thick consistency, holding a spherical shape and enclosing the ova, and adhering firmly to the silken ball. At 8.27 she completely freed herself from the drop, and then commenced to spin over it. This was accomplished by hanging with the first and second pair of legs from the web, the legs of the fourth pair in alternate use applying the thread to the surface of the drop; while the third pair of legs and the palpi were employed in concerted action so as to revolve the whole mass on its suspending silken thread. The spinnerets at this stage were not applied directly to the cocoon, From 8.27 until 8.55 she was on the left side of the cocoon, revolving it slowly from right to left; from 8.55 to 8.58 on the right side, then turning it in the opposite direction; from 8.58 until 9.00 on the left side of it, revolving it again from right to left. At this time the cocoon was of nearly its final size, almost spherical, its diameter a little greater than the length of her body. The egg mass and the original silken ball were completely covered and hidden by closely matted brownish silk. From 9.00 until 9.17 she crawled slowly over its surface, pressing against it with the tips of her palpi used alternately, evidently to mat down and smooth the whole, the feet being used simply to hold on with. At 9.17 she started applying new anchoring threads to the cocoon, this process continuing until 9.25; this was done by applying the spinnerets directly to the cocoon, then carrying each thread so fastened to an adjacent part of the web; about 15–20 such supporting threads, attached to different parts of the cocoon, were made. She rested until 10.05, then made a few more supporting lines.

♀ No. 202 likewise commenced cocooning by making a ball of curled threads, as did No. 16, her cephalothorax placed above her abdomen during the process. This continued up to 8.28 A.M., when she held her epigynal aperture against the lower surface of the ball and oviposited upon it at that point; the oviposition lasted from 8.28 to 8.31, the ova coming slowly out of the genital aperture one at a time and included in a viscid drop. At 8.32½ she commenced spinning again, covering first the lower surface of the mass of ova, then the sides, the cocoon becoming regular in form by her revolving it. This continued until 9.25 without interruption, when she stopped spinning, and instead slowly revolved the cocoon (now brown in color) and kneaded its surface with her palpi; this continued until 9.45, when she bit loose certain web lines around the cocoon, and fastened new supporting lines to it.

♀ No. 154, after making 3 normal cocoons, all suspended in her web, made a mistake in the construction of her fourth one. On July 24, at 8.13 A.M., I found her finishing the base (fluffy ball) of the fourth cocoon; but owing to some accident this was not a rounded mass of silk, but a hollow cone hung from its apex by a thick thread; the form had probably become changed by her weight upon it. From 8.20 until 8.23 she clung to this base, pressing her epigynum several times against its lower opening, and from 8.23 to 8.24 she oviposited upon it. But her weight upon the silken base had gradually unraveled the latter, so that it becoming pulled out, the egg mass sank with it to the floor, where all adhered to some dead flies. From 8.24 until 8.40 she made several ineffectual attempts to raise it into the web, then she left it and went to cocoon No. 3, spun a cap of silk first around its lower surface, then upon its sides, then kneaded this new covering with her palpal tips. Evidently she had the impression that she was finishing the cocoon already begun, and seemed to have forgotten the neglected egg mass. At 10.05 she returned to the latter and fed on the eggs, probably confusing them with the dead flies to which they adhered; at 10.10 she pulled excitedly at the neglected base, as if trying to raise it, for 6 minutes, but then left it on the floor and did not return to it again. Thus she had not been able to rectify the misshapen base of the cocoon, and under the impulse to make a covering had made this covering around an already finished cocoon.

In all these cocoonings, then, a base of a spherical mass of loosely curled silk is first formed, the ova (included within a viscid drop of fluid) deposited upon its lower side, then the whole covered with silk, finally this covering kneaded with the ends of the palpi. The reason why the external surface of the cocoon is brown in color I cannot say; possibly the silk secreted last may be different chemically—*i.e.*, proceed from different spinning tubes. In one case a complete cocoon was made without oviposition.

A succession of cocoons are formed by the same individual, the number of those made by my captives with the dates of their construction being as follows:

(1) ♀ No. 6: May 19 (the ova did not develop).

(2) ♀ No. 16: May 25 (hatched June 28); June 14 (hatched); July 7 (eggs did not develop); July 14 (eggs did not develop); July 24 (hatched); July 31 (only a few of the eggs hatched); August 21 (hatched). 7 cocoons in all.

(3) ♀ No. 129: June 2 (hatched June 14); June 24. 2 cocoons.

(4) ♀ No. 154: June 3 (hatched June 15); June 8; June 24 (hatched); July 24 (this was the incompleted cocoon described above, the eggs shriveled up); August 6 (eggs did not develop); August 15 (only a few of the ova hatched); September 1 (hatched). A total of 7 cocoons.

(5) ♀ No. 156: June 28 (this cocoon contained no ova).

(6) ♀ No. 202: June 14 (hatched June 28); June 24 (hatched July 8); July 3 (hatched July 14); July 12. A total of 4 cocoons.

(7) ♀ No. 204: July 14, the ova after a few days were shaken out of this cocoon into a test-tube to see if they would develop, and they all hatched on June 26.

(8) ♀ No. 253: July 24 (hatched August 4); July 30; August 6; August 16; August 27. A total of 5 cocoons.

Probably the rapidity in the succession of the cocoons is directly dependent upon the richness of the food supply. The time of hatching would be dependent, among other factors such as temperature, upon the thickness of the cocoon covering through which the young have to escape.

Care of the Young.—There seems to be solicitude for neither the cocoons nor the young, though the mother will not eat the latter. The mother does not guard the cocoons, and she stays near them simply because they are generally placed in that highest portion of the web where she is accustomed to dwell. Sometimes on the introduction of a fly, the mother will enshroud it alongside of a cocoon, and after sucking it dry, will cut it, with the cocoon, loose from the web; such fallen cocoons are not lifted again into the web. The young, on hatching, move in the direction of the strongest light, whereas mature individuals avoid the light; this instinct would serve to scatter them from the maternal home.

Feeding.—Living prey is recognized entirely by its pulling upon the web lines; and this species is one of the boldest of our local spiders, attacking without hesitation insects and spiders much larger than itself. That is, the females do, but the males are much more timid. A rush is made toward the struggling insect, a line of silk attached to it, and then the spider, hanging by her first pair of legs, applies the issuing silk thread to the victim's surface by the very rapid application of the three last pairs of legs. Not until the victim is closely enshrouded does the spider bite it, and she enshrouds just up to that point when the victim is rendered motionless by the envelope of silk. Often the enshrouded prey is carried to another part of the web to be eaten; and after being sucked dry is bitten loose from the web and allowed to fall out of it.

Teutana triangulosa Walck.

This is locally quite a common species in houses, but much less abundant than *Theridium tepidariorum.*

The following individuals were kept in captivity: ♂ No. 173, captured June 4, killed by ♀ No. 70, June 19; ♀ No. 70, captured May 8, killed by accident August 15; ♀ No. 153, captured May 28, died July 22; ♀ No. 176, captured June 5, still living.

Mating.—Four different males of *Theridium tepidariorum* were placed upon the web of ♀ No. 70, but she was hostile to each. On three different occasions ♂ No. 173, of her own species, was placed upon her web; she signalled to him by pulling upon the web lines, shaking her first pair of legs, but he avoided and was finally eaten by her. Her mode of signalling was like that of *Theridium tepidariorum.*

Cocooning.—This process I saw only once. ♀ No. 153 was seen at 9.05 A.M., June 15, to have spun a small ball composed of looped threads suspended in the web; she continued to add to it until 9.10, holding to the lower surface of the ball ("base" of the cocoon) with her ventral surface turned toward it, raising her spinnerets to apply them to the ball, dropping them, then raising them again for another application, the length of the "stroke" accounting for the looseness of the threads. At 9.10 she placed her genital aperture close to the lower surface of the silken ball, and deposited there a globular, viscid mass enveloping ova; this oviposition lasted just half a minute. Then she immediately began spinning over the egg mass, laying down long threads upon it, making the covering spherical by revolving her body around the cocoon, whereby she first supported herself by the surrounding web lines, later by hanging to the cocoon itself. She stopped spinning at 9.21. The cocoons of this species are snowy white, spherical, and peculiar in that they are so loosely constructed that the yellowish egg mass may be seen through them.

In natural position the cocoons are hung high in the web, generally attached to some object (such as a board) that roofs over the web; in captivity some of the cocoons were attached to the roof of the cage in conformity with this habit, but as often they are placed lower in the web. In natural conditions, also, the cocoons are generally placed close together, in that part of the web where the spider spends most of her time.

The number of cocoons made by my captives, and the dates, were as follows:

(1) ♀ No. 70: May 21, June 3, 15, July 18, 26, August 2, 13. A total of 7 cocoons.

(2) ♀ No. 153: June 2 (hatched June 27), June 8 (hatched August 14), June 15 (hatched July 17). A total of 3 cocoons.

(3) ♀ No. 176: June 15, 26 (hatched July 16), July 10 (hatched July 30), 16, 27, 31, August 5, 15, 21, 28. A total of 10 cocoons.

Care of Young, Feeding Habits.—I found no indications of maternal guarding of the cocoons or young, but the mother appears indifferent to both. It is the habit of this species, after sucking a victim dry, to cut it loose from the web, and at such times a cocoon is sometimes cut loose also, and then not raised again into the web. This species is very courageous and rushes at large flies, quickly enshrouding them with silk, which is applied with the fourth pair of legs; sometimes the struggling victim chances to be in contact with a cocoon, and then the spider frequently enshrouds both together. The young cut their own way out of the cocoons.

Steatoda marmorata (Hentz).

One male and five females were kept in cages.

Mating.—♂ No. 46 was placed upon the web of a female, both remained motionless for a while, then she killed him. Another female killed an introduced male of *S. borealis* (Hentz).

Cocooning.—This was seen only once, and only the end of the process observed. At 7.30 A.M., May 28, I found that a female had oviposited upon a mass of silk, and was then engaged in spinning over it. The spider held to the cocoon with her feet, and spun upon it (not using the legs to apply the thread) by attaching the spinnerets at one point, elevating them, and applying them again close to the first point of attachment, thus forming looped threads; in one minute I counted 22 such applications of the spinnerets. The spider in spinning slowly rotates around the cocoon. The cocoon is suspended in the web, white in color, spherical and rather loosely made. In no case were more than 2 cocoons made.

Feeding Habits.—This species is relatively very powerful and courageous, and quickly overcomes its victims by discharging upon them a thread that is remarkably viscid and tenacious; minute viscid drops can be seen upon this thread with the naked eye. This is a process of enshrouding that consists, not in wrapping the victim in threads, but rather in pouring out the very sticky secretion upon it. The spider stands upon her first two pairs of legs with her posterior end toward the object of prey, and applies the viscid thread to the latter with her other legs.

Linyphia clathrata Westr.

Moult.—At 6.40 P.M., May 7, I dropped a male of this species on to the floor of a cage, and after a few minutes he fell upon his left side and commenced to moult. His palpi and all four pairs of legs were held straight at right angles to his ventral surface. The whole process lasted somewhat less than five minutes. The old skin split by a horizontal break, just below the eyes anteriorly, and on the sides just above the legs and along the sides of the abdomen; thus it opened in two pieces, a dorsal and ventral, which remained connected together by a narrow strip close to the spinnerets. His repeated jerking flexions of the cephalothorax gradually freed first his cephalothorax, then his legs and abdomen. After the moult he rose to his legs, but was unable to walk until the expiration of 16 minutes.

Pholcus phalangioides Fuessl. Pl. IV, fig. 3.

Individuals observed, males: No. 87, captured May 16 on the web of ♀ No. 86, killed by ♀ No. 82, May 27; No. 88, captured May 17, killed by female No. 12 the same day; No. 175, captured June 5, died June 7; No. 180, captured June 7, escaped June 16; No. 245, captured June 23, died June 26.

Individuals observed, females: No. 9, captured April 29, still living; No. 12, captured April 29, died August 15; No. 15, captured May 1, moulted May 24, still living; No. 82, captured May 15, moulted May 22, still living; No. 86, captured May 16 (on the same web with ♂ No. 87), killed May 31, and immature at death; No. 174 captured June 5 (with a cocoon), died July 5; No. 179, captured June 7, died June 25 (from starvation); No. 181, captured June 7, died August 7.

Mating.—The following data include the more important observations:

(1) ♀ No. 9. On June 5, at 12.49 P.M., after she had been well fed, ♂ No. 175 was placed on her web. He first remained quiet, then touched her with his legs; at 12.56 she reached toward him and he fell from the web. At 1.06 he climbed into the web, and she moved toward him. At 1.25 he hung below her and touched her fore-legs with his, when she drew her legs away, he continuing to stretch out his first pair of legs toward her. She had in the meanwhile drawn up to herself a former enshrouded victim, and this intervened between them when, at 1.43, he tried to embrace her, so that he removed it and touched her head with his chelicera. She hung perfectly motionless in her usual position, her abdomen above her cephalothorax and directed vertically upward. The position of his body was the same, but his legs were outside of hers. At 1.47 he inserted both palpi at once, and hung to her by them, his weight pulling her abdomen into the horizontal plane. The position of the two in copula was then as

follows: The female with her abdomen horizontal and ventral surface down, her cephalothorax flexed at an angle downward; the ♂ below her, his cephalothorax about vertical and his head almost touching the ventral surface of her abdomen at the anterior end of the latter, his abdomen flexed at more than a right angle with his cephalothorax; the long axis of his abdomen thus made a wide angle with the long axis of hers, like a V. Thus they continued motionless until 2.19, when he dropped to the floor, and when he attempted to climb into the web again she chased him so vigorously that I removed him. On June 7, at 7.55 P.M., ♂ No. 180 was put in; they embraced in copulatory attitude for a minute, but she moved her legs, and he left her and went to another part of the web. At 8.17 she tried to enshroud him, so I separated them. On June 14 I put in ♂ No. 180 again, at 4.36 P.M.; he remained quiet for six minutes, then climbed up and touched her, whereupon she made her shaking motion. He then hung beneath her, shaking the web very gently by a swaying of the whole body, she responding in a similar way. At 4.47 she rushed at him, and I removed him.

(2) ♀ No. 12 killed and ate mature ♂ No. 88 on May 17, and an immature ♂ on May 24, and made her first cocoon on May 27. On June 23, ♂ No. 245 was introduced at 12.12 P.M. (the cocoon had hatched on June 15). At 12.21 he started to move with long pauses, while she was above him in the web and testing his movements by drawing the web lines taut. At 12.28 he inserted his palpi in her epigynum for a second, then fell to a lower position upon the web. At 12.30 he made several attempts to insert both palpi, and succeeded half a minute later. The position of the two was as in the preceding case, she hanging in the web by her posterior three pairs of legs, he hanging to her by his inserted palpi, his anterior three pairs of legs loosely embracing hers (and their claws hooked to web lines), his fourth pair of legs directed behind him and also hooked to web lines. The palpi were inserted by pressing them in this flexed position along the ventral surface of her cephalothorax backward to her epigynum. When inserted, a large vesicle or sac was evaginated from the lateral side of each palpal organ. I watched the copulation from 12.30 to 12.55, when I was obliged to leave, and on my return at 1.25 found them separated, he feeding on a beetle which she had previously enshrouded.

(3) ♀ No. 82. I put ♂ No. 87 with her from May 17 to May 22, when he was repeatedly observed to make advances toward and to touch her, but she acted slightly hostile to him and no copulation was

seen. She moulted on May 22. On that day (he had remained all this time in her cage) I watched a curious kind of courtship between them from 8.00 to 9.40 P.M. They hung opposite each other in the web, he by his first pair of legs, she by her first and second, reaching out and parrying with their other legs. His head pointed directly downward, her body in a horizontal position with the dorsal side down. During this process, which continued with few interruptions during the period of observation, he changed his position only slightly, while she moved about somewhat. Sometimes he made a short advance toward her, then not holding his palpi directed anteriorly (as usual) but with their stalks bent ventrad, so that the large palpal organs were bent upon his cephalothorax; at each such attempt at copulation the striking of her legs against him seemed to frighten him, and he withdrew. Both became quiet at 10.00. If this was a courtship, she appeared more active in it than he. On May 23, 24 and 25 I watched the pair at intervals, but saw no copulation. But at 10.20 P.M. on May 26 I found them in copula; they certainly had not been more than 15 minutes in that act. This copulation lasted without interruption to 11.31. Then he climbed to the bottom of the cage, when she actively chased him, and finally contented herself with feeding upon a former enshrouded victim. The attitudes of the two were as in the preceding cases. Both palpi were continuously inserted at once, and neither withdrawn, though each at intervals underwent a slight lateral movement; they were so firmly fixed in her epigynal apertures as to bear the greater part of his weight; at each side of each palpal organ was clearly visible an evaginated, rounded sac, which collapsed after the withdrawal of the palpi. This male had lost his third pair of legs; with his fourth pair directed caudad he hung to the web; the left foot of his second pair was hooked to the tarsus of the left leg of her second pair; the right foot of his second pair was hooked to the tarsus of the right foot of her fourth pair; the left tarsus of his first pair rested against the left tarsus of her fourth pair; and the right tarsus of his first pair rested upon the tarsi of her first and second pairs. Next day she killed this male.

(4) While her young were scattered upon her web, I put in ♂ No. 245 to ♀ No. 174. At the end of five minutes she rushed at and tried to enshroud him, when I separated them.

From these observations it is apparent that there is no real courtship on the part of the male; he approaches her with great caution, tentatively touching her with his legs, and only then attempting copulation when she remains immovable under his touches. In all the cases the female attempted to kill the male after copulation, and very frequently before; then he escapes by falling from the web, and always approaches her from beneath. The time of copulation varied from 11 to 32 minutes.

Cocooning.—The making of the cocoon I have not seen, though I have watched pregnant females for long intervals in the hope of seeing it. Pokrowsky (1899) is the only writer who has described this process. The cocoon is a very thin, white, silken covering to the globular mass of eggs; so thin and flimsy that we can be sure that there is a real silken cocoon only by the white case that is left after the young have escaped from it. The number of cocoons furnished by my captives was as follows, each date given representing the time of making of a particular cocoon: ♀ No. 9, June 24 (hatched July 12), July 26, August 30 (hatched September 23); ♀ No. 12, May 27 (hatched June 15), July 19 (this cocoon was dropped to the floor and did not hatch); ♀ No. 82, June 14 (hatched July 4), July 19 (this cocoon was dropped and did not hatch), August 16 (hatched about September 1), latter half of November, (hatched in December); ♀ No. 179, June 16 (this was dropped and did not hatch); ♀ No. 181, June 23 (this was dropped and did not hatch), July 19 (hatched August 4). Thus none produced more than 3 cocoons, and when a cocoon was dropped it did not hatch.

Care for the Young.—As numerous writers have noticed, the mother carries her cocoon suspended in her jaws. But it has always been stated that the cocoon is carried until the young hatch. While I have found this to be the case in one or two instances, I have seen more cases where the mother will occasionally suspend her cocoon temporarily by a line to the web, in order to clean herself and to feed. This is the more remarkable since rough handling does not cause the mother to loose her firm hold upon the cocoon, and her jaws are so firmly imbedded in its lining that, even when she wishes to, she has difficulty in breaking her hold upon it. Perhaps some of these cases where the cocoon falls to the ground are mishaps occasioned by the mother losing her hold upon her cocoon when trying to suspend it upon a thread. That such a suspension is frequent is shown by the following facts: ♀ No. 9 held her cocoon continuously in her jaws from June 24 up to July 2; on the latter date I gave her a fly, she chased and quickly enshrouded it, then left it and went to the roof of the cage, where she spun a few fine lines, then with the help of her second and third pairs of legs removed the cocoon from her jaws, held it with these legs while she touched her spinnerets to its surface three times, then left it hanging on the fine lines thus made, and which were attached to the roof by her third pair of legs, and went back and fed upon the fly; after this meal she returned and took the cocoon into her jaws again. She repeated this process next day with another fly, and the day following without a fly being put in. ♀ No. 12 was observed to do the same operation once with her first cocoon to secure food, and once with her second in order to clean herself. ♀ No. 82 was observed to do so also. ♀ No. 181 was observed to do so likewise in order to clean herself, and she, when regaining the suspended cocoon, first seized its envelope with her jaws, then with her legs snapped the supporting lines.

The hatching of the young has been observed before, but never very fully described, so that a few notes may be of interest. ♀ No. 82 was observed on the afternoon of July 4 holding her cocoon in her mouth, the young slowly unfolding themselves, the most superficial first; at 2.40 all the young had unfolded and hung as a great mass to her jaws; at 6.15 all had dispersed and the empty cocoon was hanging in the web. With ♀ No. 174 the process was noted in more detail. At 8.30 P.M. the young were beginning to unfold their legs at the lower side of the cocoon, which the mother still held in her jaws; the more superficial of the spiderlings stretched themselves, and by the enlacement of their legs together, and enlacement with the legs of those that succeeded them, there was attached to the mother's jaws a great mass of young spiderlings, a mass of a diameter fully equalling the length of the mother's body. Next morning early I found all the young, nearly 60 in number, distributed over the web, the mother motionless near them, and lower in the web the empty cocoon. ♀ No. 12 acted differently. On June 15, at 2.30 P.M., I found the young spiders beginning to escape from the cocoon, which in this case was suspended from the web, and not from the mother's jaws. At 2.35 she tore away with her jaws a portion of the cocoon, which allowed the young to emerge more easily; this she repeated at 2.40 and 2.43, each time avoiding biting the young spiders. By this time about 17 of the young were upon the web, and the mother moved about the young, spinning, and careful not to injure them. At 3.40 I put a large beetle (*Chauliognathus* sp.) upon her web, which became entangled there and shook the web. For a minute the mother remained quiet, then went to the mass of young which had not yet become scattered, and enshrouded it with silk as she does a victim, but more slowly; then carried it with her jaws. I watched her until 6 o'clock; at intervals she left the enshrouded mass of young hanging on the web, but always returned to it again to take it in her jaws, and sometimes tore at the silken shroud with her jaws. At 6.15 she started energetically tearing open the shroud, but all the young did not emerge from this silken envelope until a couple of days had passed. It is difficult to explain this act: did she enshroud the young to protect them from the beetle? Or did she enshroud them mistaking them temporarily for the beetle?

Feeding.—It fills one with admiration to watch this feeble spider, with her weak jaws and long hair-like legs, overcoming prey much larger and stronger than herself. It is done by enshrouding the victim with great rapidity. In the operation the spider rushes at the victim, then with cephalothorax up and abdomen down applies with her fourth pair of legs, these legs used in very rapid alternate action and sometimes aided by the third pair, a thread issuing from her spinnerets to the victim, and so within a short time renders it immovable. In case web lines interrupt the free action of her legs, she stops her work to bite these lines loose. The act of enshrouding lasts until the victim is nearly hidden by the thread around it, and completely powerless to move, when the spider carries it hooked to her fourth legs up to a higher place in the web and feeds upon it there. The prey is sucked dry, then cut loose from the web. The agility and strength evinced by this spider is marvelous.

The Shaking Habit.—This is the well-known habit this species has of shaking the body so rapidly by a rotary movement, while in the web, as to render itself almost invisible. Certain Epeirids have the same habit. With *Pholcus* it is an expression of fear, and is resorted to after the web has been severely jarred. Once a female was seen to shake this way after a male was put upon her web; but I never saw such a case repeated, and believe that the female was shocked by some action on my part. It is never resorted to in order to secure prey.

Acrosoma gracile Walck. Pl. IV, fig. 5.

This Epeirid, common in many of the local woods, is remarkable for great sexual dimorphism. The abdomen of the female is hard and corneous, angular and prolonged into spines. The male is much smaller than the female and much more rarely found; his small abdomen is elongated and without spines. On account of these differences it seemed desirable to observe the mating process.

♀ No. 322 was captured July 23, and died August 11; she made in her cage only the foundation lines of a web, but no orb, and so was unable to catch the insects given her. ♂ No. 321 was caught on July 23, and died July 28; he also constructed no orb.

Mating.—On July 27, at 9.27 A.M., the male was dropped upon her web. At 9.31 he touched her, and copulated from 9.32½ to 9.42. She hung ventral surface up by her fourth pair of legs to the web lines, her other legs flexed close to the cephalothorax, her thorax horizontal. The male approached her from in front of her head with his long axis also in the horizontal plane, walking upon the upturned ventral surface of her cephalothorax and abdomen, when he firmly implanted his outstretched left palpus in her epigynal orifice; then keeping the palpal organ there, he swung his body round so as to bring it on the right side of her abdomen, so that now his head was upmost and a little posterior to her epigynum, and the long axis of his body was approximately parallel to an imaginary line joining her spinnerets with the most posterior spinous processes of her abdomen. Here he held on firmly with his feet to the roughened surface of her abdomen, practically out of reach of any of her legs, and was not dislodged even though part of the time she climbed about as if trying to get rid of him. A swollen evaginated sac connected with the inserted palpal organ was clearly seen in dilation, and he held his palpus inserted until it had collapsed. He then disengaged himself from her, but returned and copulated again, from 9.55 to 10.03, this time placing himself on the left side of her abdomen and using his right palpus. Then he left her again and remained quiet most of the time up to 10.30. At 10.32 he approached and touched her, she followed him and once embraced him lightly with her legs, but he avoided her. After that she climbed about, and whenever she touched one of the web lines which he was holding, by a sudden contraction of his legs he pulled the line taut; this was possibly an amatory signal. I watched the pair continuously up to 1 o'clock, but saw no further copulation nor any preparation for sperm-induction.

Epeira labyrinthea Hentz.

Of this abundant and beautiful Epeirid only two individuals were watched. ♂ No. 281 was captured July 2, moulted July 5, died about September 1 (from hunger). ♀ No. 280 was captured July 2, moulted July 13 and 18, and died (from hunger) about October 1. This species, as well known, fabricates a labyrinth of lines behind a vertical orb; the female made such a complete web, but the male made no orb.

Mating.—After the female had constructed her web and had made 1 cocoon, the male was dropped upon her labyrinth on July 26, at 8.07 P.M. She was in her usual position, just beneath her cocoon, placed high in the labyrinth. He remained immovable until 8.39, when he began to climb about, alternately advancing toward and retreating from her, spinning threads all the while, she remaining suspended head down near her cocoon, occasionally jerking the web lines with her anterior legs (evidently signalling). The male finally made two or three quick motions toward her, withdrew each time, then copulated with her at 8.44 and again at 8.44½. Each copulation lasted barely 5 seconds; she hung head down with legs loosely flexed, like the female of *Theridium tepidariorum,* her ventral surface turned toward him; he embraced her legs with his, head downward also, but the copulation was so rapid that I could not determine how he applied his palpi, except that both seemed to be applied simultaneously to her epigynum. He then left her and went to a corner of the cage, where he vigorously cleaned his palpi and legs up to 8.58; while she remained quiet in the same place. There was no sperm-induction up to 10.00 P.M., when I left them together; he remained upon the labyrinth of her web up to the time of his death, and the pair seemed perfectly amicable.

There is no courtship, the male finds the female by pulling upon the lines of the web, and her answering pulls are evidently a signal to him of desire upon her part. In natural conditions several males are often found at once upon the labyrinth of the female.

Cocooning.—This female constructed five cocoons, on July 26, July 31, August 9, August 19, and August 27 respectively. In accord with the well-known habit of the species the cocoons were placed in a chain one below the other, the latest formed cocoon being the lowest; the cocoons are brown in color, biconvex, rather conical above and more rounded below and irregularly circular in greatest outline. Though the process of cocooning was not seen, it is very probable that the cocoon is formed of a base and a cover, and that the base is placed highest, and for these reasons: First, there is a well-marked line around the equator, showing a union of two parts. Second, the female, before cocooning, constructs a little tent, in the form of a shallow inverted cone, placed high in the labyrinth, and rests beneath it; this cone is an admirable protection against rain and sunlight, and serves to partially conceal the spider. The males appear not to make such nests. Now when a cocoon is made the female uses this conical nest as the base, thickening it by silk, the eggs are laid in its hollow, then a more nearly flat cover of less diameter is spun to close the mouth of the cone. Then she constructs beneath this cocoon a second nest-cone in which she rests, later incorporates it into a second cocoon; and so all the cocoons are made (frequently up to the number of 6). Here the nest accordingly is later made a part of a cocoon; probably other Epeirids that make similar silken nests will be found to cocoon in much the same fashion, though I know of one exception (*Epeira benjamina* Walck.). Sitting at twilight during a heavy downpour of rain beneath some trees for protection, I saw a female of this species constructing the base of her cocoon on the under surface of a leaf, at a considerable distance from her nest (the nest is a leaf curled up and lined with silk).

Feeding.—The female rests below her conical nest supported high in the labyrinth behind the orb, and holds taut with her feet a line joined to the orb. When a fly becomes stuck to the viscid spirals of the orb, she quickly runs along the drop-line to the orb, kills it by biting (without enshrouding it), carries it back to her nest to suck it dry, then usually leaves the carcass hanging in the labyrinth. The males that are upon the web of a female during the mating season also feed upon insects caught in her orb, carrying the victims to outlying parts of the labyrinth.

Xysticus stomachosus Keys. Pl. V, fig. 7.

Individuals observed, males: No. 5, captured April 27, moulted May 15, died June 7 on account of injuries incurred in an attempt to escape; No. 108, captured May 19, escaped May 27.

Individuals observed, females: No. 4, captured April 27, moulted May 10, died August 21; No. 109, captured May 19, moulted May 24, still living.

Moult.—♀ No. 4 was found in nearly completed moult at 7.40 P.M., the exuvia adhering then only to the spinnerets. She was lying upon the floor on her left side, with her legs stretched out straight, and later fell over upon her back. She did not rise until 8.03, and 5 minutes later climbed up the wall. This moult has not resulted in any regeneration of a leg broken off six days before. The old skin was in a dorsal and a ventral piece separated by a symmetrical horizontal break, as in other spiders.

♂ No. 5 was found at 8.20 P.M., hanging head downward from the exuvia, which was fastened to the wall; he did not move until 8.38, and did not break away entirely from the exuvia until 8.43.

Mating.—This was studied by keeping a male and a female in the two compartments of a partition cage, removing the partition to see the mating; the spiders showed that they saw each other through the glass partition.

♂ No. 5 was placed with ♀ No. 4 on a number of occasions prior to May 10, the date of her final moult, and on May 13, but he avoided her each time. On May 15 he completed his final moult, but on the next day he avoided her again; this would show that sexual ardor may not show itself in the male immediately after the final moult On May 17 they were put together at 8.00 P.M. Both remained perfectly quiet within an inch up to 8.57, when she moved toward him with her first two pairs of legs outstretched; he quickly reached out his corresponding legs, seized the feet of her right fore-legs with his right fore-legs, and holding them thus (only the metatarsi in contact) he quickly revolved around her and climbed upon her back from behind. She immediately became immobile with her legs flexed close to her body. He turned about upon her back, holding her with his legs, and feeling her with his palpi. At 9.02 he reached his head downward over the posterior end of her abdomen, placed the ventral surface of his cephalothorax against the ventral surface of her abdomen so that his head was posterior to her epigynum, his abdomen accordingly extending behind hers and tilted upward; his third and fourth pairs of legs held tightly to her abdomen, while his first and second pairs were directed forward to embrace her legs. One palpus at a time he then extended straight forward and applied to her epigynum. The number of palpal applications was, using the abbreviations *r* and *l* for right and left respectively, the first numbers expressing the time extent, the second the number of insertions: r, 9.08–9.12, 8; l, 9.12–9.13½, 6; r, 9.13½–9.36½, 9, the last time inserted continuously from 9.21 to 9.36½. The black spine connected with the palpal organ was pressed into her epigynal aperture, and when so inserted an evaginated sac connected with the concave surface of the organ expanded and collapsed after the withdrawal of the palpus from the epigynum; before another insertion the palpal organ was drawn through the chelicera. At 9.38 he moved half an inch away, and she rose suddenly at 9.41.

The same ♀, No. 4, copulated several times with this male, No. 5 On each occasion their attitudes were the same. The following notes give concisely the duration of time and the number of applications of the palpi, as well the mode of approach of the male.

(1) May 18, as soon as he touched her he immediately mounted upon her back, at 12.09 P.M.; palpi applied as follows: r, 12.16½–12.21, 9; r, 12.21–12.31½, inserted continuously. Then he walked half an inch away, returned and copulated again; r, 12.37–12.41, 2 or 3; he then left and again tried to return, but she repulsed him.

(2) May 19, by touching him I brought him in contact with her he mounted her, and made the following palpal applications: l, 8.28–

8.30, 4, not effectively inserted; l, 8.31–8.33, 1; l, 8.34–8.34½, 1; l, 8.35½–8.36; l, 8.36½–8.42; l, 8.42½–8.43; l, 8.43¼–8.44; l, 8.44–8.46 1; l, 8.46½–8.47; l, 8.47½–8.50; l, 8.50–8.51; l, 8.53–8.53½; l, 8.54½–8.57½. Then she rose and shook him off.

(3) May 21, at 10.17 P.M., he touched her, kept quiet for half a minute, then climbed upon her. He left her for a few seconds at 10.25 then returned and applied his palpi as follows: l, 10.29½–10.35, 5; r, 10.35½ to 10.36, 6; l, 10.38½ to 10.41; r, 10.44½–10.46, several times; l, 10.46 to 10.48, several times; l, 10.48–10.48½, 1; r, 10.48½–10.49½, 1; r, 10.49½–10.51; r, 10.51–10.52½, 4; l, 10.53–10.55, 4; l, 10.55–10.58, 1; r, 10.58–11.08, continuously; l, 11.08–11.12, 1; r, 11.12½–11.17. He then got upon her back, remained quiet there for a while, then I separated them.

(4) May 23, he mounted her at 3.34 P.M. Then the two being in an unfavorable place for study, I pushed them to another place with a pen-handle; she gripped it, and I was obliged to shake roughly to make her leave go, but he did not loosen his hold upon her, and as soon as she had lost her grasp upon the pen-handle she immediately became motionless again with flexed legs. He applied his palpi as follows: r, 3.39–3.40, 6; l, 3.42–3.45, 1; r, 3.45½–3.46, 1; l, 3.46–3.46⅓, 1; l, 3.47–3.50, 1; l, 3.51–3.52, 1; r, 3.52¼–3.54; l, 3.54–4.00; then he walked off for a minute but returned; r, 4.03–4.04½, 1; l, 4.04½–4.07; r, 4.08–4.11; l, 4.12–4.13. He then left her, returned, did so again, but at 4.14 she arose.

(5) May 28, he was placed with her from 9.24–9.50 P.M., but there was no copulation.

(6) May 29, the male mounted her at 8.45 P.M. Palpal applications: l, 9.53–9.56⅓, 6; r, 9.56⅓–9.58½, 2. Then she began to walk about and carried him out of the open cage, and in putting them back I separated them.

(7) June 3, 8.31 P.M. She moved so as to touch him, and a minute later he mounted her. Palpal applications: l, 8.37½–8.39, several times; r, 8.39–8.40½, several times; l, 8.40½–8.45, continuously; l, 8.45½–8.57, continuously; r, 8.57½–9.01, several times; r, 9.01–9.03. At 9.05 he got upon her dorsal side again, a minute later she rose and walked off with him clinging to her. She dislodged him at 9.09, but a minute later he mounted her again, used his right palpus from 9.12 –9.13, then she rose and escaped from him.

♀ No. 109 copulated with ♂ No. 108 on May 24, and on May 25; the attitudes were as in the previous cases. On May 29 she was rather hostile to him, and whenever he tried to grasp her she ran off. Once with his first two pairs of legs he parried with hers for more than a minute, evidently trying to grasp them; then he sidled off, and when he returned she grasped him with her legs, and finally she gripped fiercely at him.

The descriptions here given may seem unnecessarily full, but they are given to show the variations in the mode of copulation, a greater variation than I have observed in any other species. In one copulation only one of the palpi was used; in the others both palpi, but in irregular alternation. The earlier palpal applications in each copulation are mainly ineffective, the palpal organ not being thoroughly inserted, and a considerable part of the time is occupied in working the palpal organ through the chelicera. Peculiar for this species is the fact of the male sometimes interrupting the copulation by leaving the female for a minute, then returning and resuming it. The longest period of copulation was 48 minutes.

There is no courtship on the part of the male, nor any instigation by the female. When the male is first put into the cage of a female, even though he faces her, he does not seem to recognize her as such by sight, and pays no attention to her until he touches her, when he quickly gets upon her back. My custom was to push him up to the female. He is considerably the smaller and the more active; and when upon her back he is secure from her legs, and is not easily dislodged by her. He mounts upon her from behind, out of reach of her long and dangerous fore-legs, and when he is mounted she immediately becomes still. His smaller size and greater activity enable him to accomplish his purpose, quickness overcoming strength. Seeing the male upon the female, one involuntarily thinks of the Old Man of the Sea, who cannot be dislodged.

Cocooning.—For some two weeks before making her cocoon ♀ No. 4 spun a network of web-lines across her cage, so dense that she frequently became entangled in them, and I was obliged to clean them away. But this is probably not to be considered a web-making, but simply the habit this species has of drawing out a thread behind when walking, a "drop-line" by which it can find its way back. On July 5, however, she made quite a dense sheet of silk in a corner of the cage, completely enclosing her and inclined at an angle from the floor to the walls. Within this she made, in the early morning of July 9, her only cocoon; this cocoon was inclined at an angle to the floor, fastened to the scaffolding, flattened, unevenly circular in outline, and white in color. It did not hatch.

♀ No. 109 built on July 5, at the angle of two walls of her cage with the floor, a similar sheet-like tent; and on July 9 made her cocoon within it. This cocoon was roughly quadrangular in outline and flattened. It did not hatch.

Care of the Young.—The cocoon is guarded by the mother, who lies upon it and embraces it tightly with her legs. ♀ No. 4 would not leave her cocoon to secure living food during the first ten days, but clung tenaciously to it; but after that she would leave it to chase prey, and afterward would return to the cocoon, or at least to the silk sheet placed before it. By climbing many times upon this silk sheet she gradually demolished it. ♀ No. 109 at first held her cocoon zealously, then neglected it for several days, and finally at this time, October 4, is embracing it again.

Philodromus aureolus Walck.

Cocooning.—A female of this species made 6 cocoons, on she following dates respectively: July 3, 30, August 9, 21, 27, September 6. All these were normal cocoons except one, which I disturbed in the process of making, but the eggs of none of them hatched. The first three cocoons were placed side by side at the angle of the wall and the roof of the cage, the others at the angle of the wall and the floor. The mother constantly stands with outstretched legs over the most recent cocoon.

Each cocoon is a flattened disk of rather loose white threads, and the mode of architecture shows that the mass of ova had been laid upon the surface of the lower disk (base), and then overspun with another disk (cover). But a peculiarity is a third disk of silk, concentric with but at a distance of about 2 mm. from the cover of the cocoon—the final protection, on which the mother stands.

Prosthesima sp.[3]

Cocooning.—On June 14, at 8.45 P.M., I saw a female just finishing her cocoon, which was discoidal in shape. She placed her feet upon its margin, and brushed her spinnerets from side to side across its surface. This was her second cocoon, and at 10.05 she started spinning again upon the wall of the cage, used her spinnerets as before, and continuing steadily up to 11.50, when I ceased to watch her. She had then made a thick silken covering, about four times her length in one direction, and half so long in the other. But she did not oviposit upon this surface, so that I cannot tell whether it was an abnormal cocoon or not.

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[3] Mr. Banks wrote me that this species comes closest to *P. insularis* Banks, but is different from it.

Thargalia brivittata (Keys.).

Cocooning.—The end of this process only was seen. The discoidal cocoon was satiny-white and placed at the angle of the floor and wall of the cage; its base was closely apposed to these surfaces so as to be bent at a right angle, while the cover (of smaller diameter than the base) was arched from the floor to the wall. In completing this cover the spider brushes her spinnerets more forward and backward than from side to side, flexing her body about energetically, while keeping her feet in one position upon the edge of the cocoon; then she changes her position over the cocoon, and repeats this process. I watched her in this process for half an hour, after which she covered the surface of the cocoon with small particles of dirt.

Drassus neglectus Keys.

Guarding of the Cocoon.—A female of this species was caught on June 10, and made a thick web within her cage. On the evening of July 7 she made her cocoon, which was white in color, discoidal with circular outline, one side flattened and the opposite side somewhat arched. This cocoon was loose, not fastened to any object, and she held its margin with her chelicera, pressing her cephalothorax against it and at times partially embracing it with her legs. Most of the time she held it in one corner of the cage, but sometimes carried it about to different portions of the cage. When I touched her she still clung to it without moving; flies were put in her cage almost daily, but she paid no attention to them, even though at times they touched her. She died on July 21, still holding the cocoon in death.

This observation is narrated, since I know of no other Drassid that guards its cocoon so carefully, nor of any that makes such a thick and large web.

General Considerations.

History of Our Knowledge.—In 1701 Leeuwenhoek, the father of histology, wrote: "I never was so happy as to see the Spiders couple, ... but what shall we say, the Coition of Spiders must differ fundamentally from other Creatures, since their Matrix is placed in the upper part of their Belly." He did not know of the observations of Lister, who in 1678 discovered that the male spider fertilizes the female by applying the enlarged terminal joint of his maxillary palpus to her epigynum. The discovery has been confirmed by a long list of observers, though a list small in comparison with the number who have sought in vain to see the process: Ausserer, Bertkau, Blackwall, Campbell, Clerck, De Geer, Dugès, Emerton, Fickert, Hasselt, Hentz, Herman, Lendl, Lesser, McCook, Menge (in numerous species), the Peckhams, Ritsema, Seidel, Treat, Walckenaer, Westberg. These confirmatory observations, embracing species of all the larger araneid families, make it very probable that in all modern Araneids the male transfers the sperm to the female by means of his palpi. Two writers have combated this conclusion: Treviranus, who first discovered the testes of spiders and, finding no organic connection between these organs and the palpi, maintained that the application of the male palpi to the epigynum is probably not real copulation, but rather a preliminary act of stimulation; and Cambridge, who states he observed two individuals of a *Lycosa* in coition, with their genital apertures in apposition. In view of the numerous observations on this act in *Lycosa*, I have no hesitation in stamping Cambridge's assertion as erroneous. In all the families where the act has been seen, accordingly, the palpal organs are the transmitters of the semen.

Now though Treviranus showed conclusively that there is no organic connection between the testes, or the vasa deferentia, and the peculiarly modified palpal organs, some later writers, particularly Cambridge and Herman, insisted that there must be some such tubular connection, in order to explain the presence of spermatozoa in the palpal organs. The results of all other anatomists, however, have corroborated Treviranus, and Menge discovered, first in the year 1843, how the sperm is brought from the genital aperture into the tubular apparatus of the palpal organs. In that paper of 1843, an arachnological classic, he described the process for *Linyphia triangularis* and *Agalena labyrinthica,* showing that the male constructs a little silken bridge or "Steg," deposits a drop of sperm from his genital aperture upon it, then applies his palpal organs alternately to the drop until they have absorbed it all; then, and not till then, is the male ready for copulation. This process of charging the palpi with sperm, which I have termed here "sperm-induction," was described by Menge later also for *Tapinopa longidens, Agalena similis* and *Micrommata virescens.* The only other writers who have described this process are Blackwall (1863, in *Agalena labyrinthica*), Ausserer (1867, in *Dictyna benigna* and *Linyphia triangularis*), Bertkau (1875, 1876, in *Philoica domestica, Linyphia montana* and *Clubiona comta*), Westberg (1900, in *Linyphia triangularis*). To these may be added my present observation on *Lycosa stonei, L. ocreata pulchra, Tegenaria derhami, Theridium tepidariorum* and *Dictyna volupis* (here seen twice). Hasselt was unable to see this process himself, and on that account doubted whether it is of general occurrence among spiders.

The Mode of Embrace in Copulation.—Grouping together my own observations with those of other naturalists, and bracketing the authority for each case, the following modes of embrace may be distinguished in spiders:

(1)—The male above the female with his ventral surface apposed to her dorsal, their heads pointing in opposite directions,
(*a*)—Female with her sternum down: *Lycosa stonei, L. ocreata pulchra, L. scutulata* (Montgomery), *L. monticola* (Clerck), *L. amentata, L. rurestris* (Menge); *Trochosa infernalis* (Lendl), *T. terricola* (Menge); *Pardosa nigropalpis* (Montgomery); *Sparassus* (Bertkau); *Epiblemum scenicum, Attidæ, Enophrys reticulata* (Menge), *Attus scenicus* (De Geer); *Phrurolithus festivus, Melanophora nocturna* (Menge).
(*b*)—Female partially upon her side: *Agalena nævia* (Emerton, Montgomery), *A. labyrinthica* (Dugès, Menge, Walckenaer), *A. similis* (Menge).

(2)—The head of the male facing the head of the female, their bodies in one line,
(*a*)—Male with his dorsum directed upward, female partially upon her side: *Tegenaria derhami* (Montgomery).
(*b*)—Both with ventral surfaces directed upward, bodies horizontal: *Linyphia marginata* (Emerton, McCook), ?*Steatoda borealis* (Emerton).

(3)—Ventral surfaces of the pair apposed, sternum against sternum, heads directed in opposite directions,
(*a*)—Copulation upon a web: *Argenna* (Bertkau), *Linyphia montana* (Clerck), *Linyphia triangularis* (De Geer, Menge).
(*b*)—Copulation upon the ground,
(*b'*)—Male below the female: *Argyroneta aquatica* (Walckenaer), *Chiracanthium oncognathus* (Menge).
(*b''*)—Male above the female: *Clubiona trivialis* (Menge).

(4)—Male holding to the side of the abdomen of the female, his long axis at right angles to hers: *Acrosoma gracile* (Montgomery).

(5)—Male with his ventral surface apposed to the posterior and ventral surface of the abdomen of the female, their heads turned in the same direction: *Xysticus audax* (Prach), *X. triguttatus* (Emerton), *X. stomachosus* (Montgomery), *Misumena vatia* (De Geer), *Micrommata virescens* (Menge).

(6)—Ventral surface of the male turned toward the ventral surface of the female, their heads turned in the same direction, copulation in a web,
(*a*)—Bodies not in actual contact, but heads converging: *Epeira labyrinthea* (Montgomery), *E. diademata* (Menge, Lendl), *Theridium tepidariorum, Pholcus phalangioides* (Montgomery).

(*b*)—Long axes of the bodies converging so that the forehead of the male touches the sternum of the female: *Dictyna volupis* (Emerton, Montgomery), *D. benignum* (Walckenaer), *Micryphantes rurestris* (Hasselt).

(*c*)—Male with his sternum apposed to that of the female: *Dictyna ammophila* (Menge).

(*d*)—Male apposed to the ventral surface of the abdomen of the female: *Nephila*, *Argiope* (Emerton), *Meta segmentata*, *Asagena serratipes* (Menge).

(*e*)—Male holding the chelicera of the female with his own, the abdomen of the female flexed ventrad: *Pachygnatha listeri* (Menge), *Tetragnatha extensa* (Bertkau, Dugès, Menge, Lister, Walckenaer).

The following table illustrates the distribution of these modes of embrace among the families observed:

Family.	MODE OF EMBRACE.												
	1*a*	1*b*	2*a*	2*b*	3*a*	3*b*	4	5	6*a*	6*b*	6*c*	6*d*	6*e*
Lycosidæ	+												
Sparassidæ	+												
Attidæ	+												
Drassidæ	+					+							
Agalenidæ		+	+										
Theridiidæ				+	+				+			+	
Argyronetidæ						+							
Epeiridæ							+		+			+	+
Thomisidæ								+					
Pholcidæ									+				
Dictynidæ										+	+		

The species which have been observed are too few to allow broad generalizations, but the following points may be noted. In all the species it is the male that embraces the female, she remaining motionless; the male embraces with his legs, and in *Tetragnatha* and *Pachygnatha* with his chelicera also. The mode of embrace may well be dependent upon one of several different factors: (1) relative size of male and female; (2) differences in their form; (3) differences in place of copulation (whether upon a web or upon the ground). The fact that the typical terrestrial spiders which do not build webs (*Lycosidæ, Sparassidæ, Attidæ,* certain *Drassidæ*) all show the same mode of embrace might point to similarity of place of copulation, in unison with the running and hunting habits of these species, inducing similarity of mode of embrace, and be referable to the third factor;

while the diversity of embrace in the web-making species may be in part due to differences in the web construction, in part to degree of sexual dimorphism. The *Epeiridæ* and *Theridiidæ* show the greatest diversity of embrace, and in these families is to be found also the greatest sexual dimorphism. In other words, the mode of embrace may be brought into more or less conformity with the general mode of life of the species. Similarity of embrace points, then, to similarity of other habits, but not necessarily to community of descent. No spider shows the attitude of embrace common among insects, namely the male above the female with his head pointed in the same direction as hers.

Details of the Process of Copulation.—The following table combines data of the other observers with my own upon the details of copulation. Where a species has been entered more than once, each repetition denotes a separate act of copulation. In the column "Duration of Copulation," *h, m, s,* signify *hour, minute* and *second* respectively. In the column headed "Simultaneous," the sign × denotes that both palpi are inserted at once, and the sign — that they are not. In the column headed "Alternated," the sign × indicates that the right and left palpi are inserted alternately, but that the number of alternations was not noted; the sign —, that only one palpus is employed; while a number expresses the number of alternations of the right and left palpi. In the columns headed "Right Palp" and "Left Palp," a number enclosed in brackets denotes the average number of times one palpus is inserted successively before the other palpus is inserted, this average being obtained by dividing the total number of insertions of that particular palpus by the total number of alternations of the palpi. Spaces left vacant in the columns denote lack of observations. For the great number of small details that cannot be reproduced in such a table, the reader is referred to the observational part of this paper, and to the works mentioned in the literature list.

	Species.	Authority.	Duration of Copulation.	Application of Palpi.		Number of Palpal Insertions.		
				Simultaneous.	Alternated.	Total Number.	Right Palp.	Left Palp.
LYCOSIDÆ.	*Lycosa stonei*	Montgomery	13 m.	—	12	105	48 (4)	57 (4.7)
	Idem	*Idem*	1 h. 15 m.	—	12	126	53 (4.4)	73 (6)
	L. ocreata pulchra	*Idem*	47 m.	—	8	64	31 (3 9)	33 (4.1)
	Idem	*Idem*	1 h. 27 m.	—	15	140	68 (4.6)	72 (4.8)
	L. scutulata	*Idem*	59 m.	—	42	98	52 (1.2)	46 (1)
	Idem	*Idem*	55 m.	—	81	167	85 (1)	82 (1)
	L. lugubris	Blackwall	4 h	—	+	Several hundred		
	Idem	*Idem*		—	+		80	80
	L. rurestris	Menge		—	+		(6)	(6)
	L. amentata	*Idem*	7 h.					
	Pardosa nigripalpis	Montgomery	9 m.	—	+			
	Idem	*Idem*	7 m.	—	1	24	6 (6)	18 (18)
	Trochosa infernalis	Lendl	65 m.	—	+	109		
	T. reticulata	Menge	3 h.	—	+			
EPEIRIDÆ.	*Acrosama gracile*	Montgomery	8–10 m.	—	—	1		
	Epeira labyrinthea	*Idem*	5 s.	+?				
	E. diadema	Ausserer	A few seconds					
	E. quadrata	Herman	36 h.					
	E. callophylla	Walckenaer	20 m.	—	+			
	E. marmorea	Menge	1 s.					
	Tetragnatha extensa	Dugès	15 m.	—	+			
	Idem	Menge	1 h.	—	+			
	Meta segmentata	*Idem*	Several minutes	—	—			
	Pachygnatha listeri	*Idem*	3 h.	—	1			
THERIDIIDÆ.	*Theridium tepidariorum*	Montgomery	5–15 s.	+	—	1	1	1
	T. quadripunctatum	Menge	2 h.	—	1			
	Linyphia triangularis	De Geer Menge Westberg	2 h. 30 m.	—	Every 10 s.–3m.30s			
	L. montana	Walckenaer	40 m.	—	+			

	Species.	Authority.	Duration of Copulation.	Application of Palpi.		Number of Palpal Insertions.		
				Simultaneous	Alternated.	Total Number.	Right Palp.	Left Palp.
THERIDIDÆ.	*Linyphia marginata*	McCook	2 h. 55 m.	+	+			
	Steatoda borealis	Emerton	1 h. 15 m.					
	Stylophora concolor	Menge	2 h.	—	+			
	Tapinopa longidens	*Idem*	4 h.	—	+			
	Asagena serratipes	*Idem*	1 h.	—	—	1		
	Eucharia bipunctata	*Idem*	2 h. 30 m.	—	—	1		
DICTYNIDÆ.	*Dictyna benigna*	Ausserer	30 m.	—	6	6	3	3
	D. ammophila	Menge	2 h.	—	+	4	2	2
	D. volupis	Montgomery	At least 1 h.	—	—	1		1
	Idem	*Idem*	At least 50 m.	—	—	1		1
	Idem	*Idem*	51 m.	—	—	1	1	
	Idem	*Idem*	At least 34 m.	—	—	1	1	
	Idem	*Idem*	2 h. 18 m.	—	1	2	1	1
	Idem	*Idem*	At least 1 h. 16 m.	—	1	2	1	1
	Idem	*Idem*		—	—	1		1
	Idem	*Idem*		—	—	1		1
AGALENIDÆ.	*Tegenaria derhami*	*Idem*	5 s.	—	—	1		
	Idem	*Idem*	1 m.	—	—	1	1	
	Idem	*Idem*	2 m. 45 c.	—	2	3	2	1
	Agalena similis	Menge	3 h.	—				
	A. nævia	Montgomery	7 h. 45 m.	—	2	3		
	Idem	*Idem*	More than 8 h.	—	1	More than 53	More than 22	31
	Idem	Emerton	Several hours	—	1			
	A. labyrinthica	Bertkau	1 h.	—	1	60–80	30–40	30-40
	Idem	Menge	More than 3 h.	—	1			
DRASSIDÆ.	*Melanophora nocturna*	*Idem*	At least 30 m.	—	1			
	Phrurolithus festivus	*Idem*	3 h.					
	Chiracanthium oncogathus	*Idem*		—	1		15 m. at a time	15 m. at a time
	Clubiona trivialis	*Idem*	Several hours					

	Species.	Authority.	Duration of Copulation.	Application of Palpi.		Number of Palpal Insertions.		
				Simultaneous	Alternated.	Total Number.	Right Palp.	Left Palp.
ATTIDÆ.	*Heliophanes cupreus*	*Idem*	30 m.	—	—?			
THOMISIDÆ.	*Micromata virescens*	*Idem*	5 h.	—	+		30 m. at a time	30 m. at a time
	Xysticus audax	Prach		—	+			
	X. stomachosus	Montgomery	27 m.	—	3	23	17	6
	Idem	*Idem*	25 m.	—	—	12	12	
	Idem	*Idem*	28 m.	—	—	14		14
	Idem	*Idem*	48 m.	—	6	33	17	16
	Idem	*Idem*	34 m.	—	6	17	10	7
	Idem	*Idem*	25 m.	—	5			
PHOLCIDÆ.	*Pholcus phalangioides*	*Idem*	32 m.	+	—	2	1	1
	Idem	*Idem*	More than 25 m.	+	—	2	1	1
	Idem	*Idem*	About 26 m.	+	—	2	1	1

From these data we may conclude:

(1) That the time duration of a copulation varies from a second, or a few seconds, to as much as 36 hours. When the copulation is very brief it is probably frequently repeated many times, a number of times in quick succession (as certain Epeirids), or repeated a number of times on successive days (cf. my observations on *Theridium tepidariorum*). When it is of some hours in duration, the female frequently, but not always, kills the male at its conclusion (certain Lycosids and Agalenids).

(2) That the simultaneous insertion of both male palpi in the epigynum is unusual (*Pholcus*, certain Theridiids). Most frequently either (*a*) only one palpus is used during the act, or (*b*) the palpi are alternated; sometimes the same male may use only one palpus during one copulation, and both palpi during another (*Dictyna volupis, Xysticus stomachosus*). When the palpi are alternated, either (*a*) one of them may be used (continuously or with successive insertions) during the first half of the copulation, and the other palpus for the second half; or (*b*) the palpi may be frequently alternated, a strict alternation of right and left after each insertion, or else one may be inserted a number of times before the other is used.

(3) That in all cases described in sufficient detail there has been noted the appearance, during insertion in the epigynum, of an evaginated, swollen sac connected with the palpal organ; the organ is not withdrawn from the epigynum until this sac collapses; this sac may expand and contract rhythmically in long insertions. After the withdrawal of a palpus from the epigynal orifice, the male works the palpal organ between his chelicera—apparently to moisten it, as has been suggested by one observer.

(4) That within a species there is to be found considerable individual variations in the details of copulation.

(5) That a particular araneid family, as at present defined, may contain species which differ quite markedly in the details of their copulation: the *Epeiridæ* are an example.

The Sperm-induction, and the Origin of the Araneid Mode of Copulation.—In the section entitled "History of Our Knowledge" all the known cases of sperm-induction are mentioned. In all these cases the male deposits a minute drop of semen upon a portion of web, and takes up this drop into his palpal organs by applying the latter to it, then shaking them in the air. There appear, however, to be some difference in the details in different species. Thus the male sometimes spins a special small sheet or bridge over which he stands, and on which he deposits the semen (*Linyphia triangularis, Agalena labyrinthica, Tapinopa longidens, Agalena similis, Micrommata virescens, Dictyna benigna, Philoica domestica, Linyphia montana, Clubiona comta, Lycosa stonei, L. ocreata pulchra, Tegenaria derhami, Dictyna volupis*); and sometimes he makes no special sheeting, but deposits the semen upon a strand of the domicile web (*Theridium tepidariorum*). In those species where the male does not construct a domicile web, but lives upon the ground, as in the *Lycosidæ* and *Drassidæ*, the male always spins a small sheeting to catch the drop of semen, and this is his only spinning act during his mature life; species that live in webs also generally construct a special sheeting for the semen. There is no known case of the male charging his palpi by placing them directly against the genital aperture. In order to see this act the observer should remove the male from the female immediately after a completed copulation, one which has exhausted the palpi of the seminal fluid, and watch for an act of sperm-induction; that is the only time when one may expect it with some certainty. In some species the male may copulate several times, and frequently charges his palpi with semen before repeating an act of copulation.

This is a very wonderful process: the male discharges semen upon a web, takes up this semen into his palpal organs, and with the latter applies the semen to the genital aperture of the female. There are, in a sense, two separate acts of seminal discharge, and at each of them, but most particularly in the second, the male shows very evident gratification. No one, to my knowledge, has endeavored to account for such a double process, which is essentially different from the "hektocotyly" of Cephalopods. It is definitely determined that the palpi (pedipalpi) of araneids and other arachnids have, in the mature state, no organic connection with the testes or vasa deferentia, that there are no tubes connecting the palpal organs with the organs in which the spermatozoa develop. In the ontogenetic development the palpi appear at first similar to the other extremities, and are separated from the genital aperture by four segments of the cephalothorax, each bearing a pair of appendages. Accordingly there is neither anatomical nor embryological reason for supposing that the palpi ever had been appendages of the genital aperture, which had later moved forward from the region of the genital aperture; they are true thoracic appendages, and not abdominal. Now the pedipalpi of *Limulus* in the male terminate each in a large swollen knob, which is used in the copulation as a clasper of the female; and in *Limulus* the distal end of each of these swollen joints opens to the exterior by a minute aperture, which is readily determined on dissection. The fact that *Limulus* is a true arachnid, and probably a relatively primitive one, allows us to use these peculiarities of structure as a partial basis for explaining the araneid mode of copulation; though the following reasoning would hold equally good, even if *Limulus* should be left out of the question. The palpal organs of male araneids must have been originally clasping organs, to hold the female. Supposing the terminal joints of the male palpi clasped the female in the region of her genital aperture, around which developed a hard chitinous plate, the epigynum, which would allow a firm hold without injury to the female, then if the original mode of embrace were that where the ventral surfaces of the copulating individuals were apposed, these two suppositions would explain the copulation of modern araneids. Depressions in the epigynum would be developed to correspond to projections upon the palpal organs. The surfaces of the palpal organs, which are apposed to one another during the act of clasping, could become in time so modified as to form together a tube to guide the seminal fluid from the genital aperture of the male into that of the female. They would thus change from mere clasping organs to intromittent sexual organs, and then perhaps the other legs come into use as clasping organs, which is their use in copulation in modern araneids. Subsequent would be the development of the complicated tubular apparatus within each palpal organ; and when this were finally developed, the habit of charging the palpi with sperm before the copulation would be involved, and then diversity in embrace and modes of application of the palpi could follow.

There is still another thinkable mode of origin of the araneid mode of copulation. The pedipalpi might be used, not as claspers in the first instance, but to carry drops of semen during the act of copulation from the genital aperture of the male to that of the female; later, the male during copulation might discharge his semen upon the web, and then take up the semen with his palpi and apply it to the female; still later, the charging of the palpi with the semen would come to be an act separate from the copulation.

One or the other of these has been probably the mode of origin of the habit, but which cannot be decided until observations have been made upon the mating of the most primitive living araneids, the *Tetrapneumones*. Very apposite in this connection are the interesting and detailed observations of my friend Heymons[4] upon *Galeodes*. In this primitive arachnid the male forcibly seizes the female, holds her with her legs, she falling into a state of torpor in his embrace. With his chelicera he pinches the ventral surface of her abdomen, which is turned toward his, until he finds the cleft of her genital orifice. "Die Cheliceren werden herausgezogen, nochmals eingebohrt, und das Männchen kneift auch wohl wiederholt mit denselben in die weichen Wandungen des Ostium genitale. Es dauert nicht lange, so tritt die ganze weibliche Genitalpartie wulstförmig hervor, und die Genitalöffnung wird als ein klaffender Spalt erkennbar. Die Erregung des Männchens hat nunmehr den Höhepunkt erreicht; zitternd bewegt es beide Maxillarpalpen und hebt den Hinterleib ein wenig, aus dessen Genitalöffnung ein zähflüssiger klebriger Spermaballen hervorquillt. Kaum ist dieser auf den Boden gelangt, so wird er auch schon blitzschnell von den Cheliceren des Männchens aufgenommen und an die weibliche Genitalöffnung gebracht. Hierauf stopft das Männchen, abwechselnd die rechte und linke Chelicere benutzend, die zähe Spermamasse in die Oeffnung hinein, wobei es wieder mit grosser Gewaltthätigkeit zu Werke geht." The process is simpler in *Galeodes,* inasmuch as the sperm is discharged during the act of copulation, and inasmuch as the terminal joints of the chelicera do not possess any intricate tubular apparatus for holding the sperm. But the araneid copulation cannot be derived from the galeolid, since in the former the pedipalpi, in the latter the chelicera, are employed. In the *Acarina* and *Scorpionidea* there are intromittent organs (penis) in the male, placed near the genital orifice.[5]

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[4] "Biologische Beobachtungen an asiatischen Solifugen," *Abh. Preuss. Akad. Wiss. Berlin*, 1901.

Number of Copulations.—In araneids the male is able to perform a number of successive copulations, with the same or with different females, without being exhausted; this fact may be brought into relation with the fact that before each act of sperm-induction only a small drop of sperm is discharged, and by no means the whole contents of the testes. One act of fertilization is in some cases sufficient to fertilize a number of cocoons, yet not infrequently several distinct copulations may precede one cocooning. This is in contrast to the case in insects, where the male generally performs a single act of copulation, and dies of exhaustion after it. The female sometimes kills the male after copulation, but this is by no means so general as usually supposed, for frequently both sexes may live in harmony for a considerable length of time. The reason that in many species the females appear more abundant than the males (particularly in *Epeiridæ*), is not to be ascribed to any initial disparity in the number of the sexes, nor yet to the males being killed by the females, but to the females being of stronger constitution. Thus, in the case of the individuals watched by me, the males died sooner from hunger and thirst than did the females, and each act of copulation appeared to diminish their vitality. When one collects in the early part of the mating season the males are generally found fully as abundant as the females, while later in the year they may become, in some species, very rare.

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[5] In all insects the intromittent organ of the male is organically connected with the vas deferens, except in the *Odonata* where, as is well known, this organ is placed on the second abdominal segment, and the male holds the head of the female with the claspers of his last abdominal segment. My colleague, Dr. P. P. Calvert, the well-known monographer of the *Odonata,* tells me that he has seen the male charge his penis with semen just before copulation by bringing his sexual orifice against this organ.

Parthenogenesis.—Two cases of apparent true parthenogenesis, with the production of fertile eggs, have been described by Campbell (1883) and Damin (1893). A number of females observed by Blackwall (1845), where he excluded males and kept the females through a number of moults, made cocoons and laid eggs, but the latter proved infertile. Eggs frequently prove infertile even after copulation, according to my own observations. Parthenogenesis, with the production of fertile eggs, is then very rare among spiders, and it is probable that most species do not show it at all. Blackwall's observations (1845*a*) are quite decisive upon this point.

A very curious case is that described by Doumerc (1840) of a *Theridium triangulifer* which made successive cocoons, out of some of which only male spiderlings developed, out of others only females. This is a phenomenon well worth critical study.

Cocooning, Oviposition.—I shall not attempt to give here a comparative study of cocoon-architecture; that subject has been well treated by Wagner, and much less accurately by McCook; but shall simply call attention to the similarity that exists among all observed species in the general modes of cocoon-making and oviposition. The first stages of this process have not been frequently described, and the following list comprises all the observations on the subject: Leeuwenhoek, Menge (*Lycosa, Tegenaria, Gnaphosa, Micaria, Philodromus*), Emerton (*Epeira*), McCook (*Lycosa*), Henking (*Lycosa*), Pokrowsky (*Pholcus*), Warburton (*Agalena*), Wagner's excellent studies on a number of species, and my own (*Lycosa stonei, L. lepida, L. punctulata, L. ocreata pulchra, Pardosa nigripalpis, Pirata liber, Tegenaria derhami, Theridium tepidariorum, Teutana.*). In all of these the spider spins first a base, oviposits upon it, then spins a cover over it; all araneid cocoons are made in this way. McCook (1890) distinguishes three kinds of cocoons, and states of the third kind (supposed to be characteristic of the *Lycosidæ*): the spider spins "a single sheet, within which the eggs are deposited, which is subsequently pulled over the egg mass, and pinched by the jaws into a globular covering, the selvage of which is united with sufficient firmness to adhere until the spiders are ready to leave the cocoon." As a matter of fact, such a type is not known among spiders. McCook had based it upon an imperfect observation of his own (in 1884); Menge had described the process in *Lycosa* correctly as long ago as 1843, and Henking, Wagner and I corroborate Menge, that the cocoon is made in the *Lycosidæ* of two separate portions, a base and a cover. No matter what the final shape of the cocoon may be, nor how the mother places or carries her cocoon, it is always made of two separate portions. These may each be a disk (*Lycosidæ, Drassidæ, Thomisidæ, Dictynidæ, Agalenidæ*), or the base may be a spherical ball of silk (some *Theridiidæ*). The mode of oviposition also appears to be uniform in araneids; the eggs are discharged upon the base of the cocoon included in a large drop of fluid of very viscid consistency; this drop serves to retain the ova in a compact mass, and to protect them from the air before the cover of the cocoon is made. This drop of fluid is of such bulk that only a small portion, if any, of it can consist of semen, and it is probably a secretion of glands connected with the female generative apparatus. Bertkau was unable to find spermatozoa within this fluid.

The act of oviposition does not weaken the spider, and in some species one individual produces a number of cocoons in succession. Females have been known to live for several years.

Care of the Cocoons and Young.—The *Lycosidæ,* as is well known, carry the cocoon attached to the spinnerets, and carry the young upon their bodies for some time after hatching; but the mother does not feed the young, as Kirby supposed. The Lycosid genera *Dolomedes* and *Ocyale,* however, carry their cocoons in a different manner and build a nest for the young. I have seen also that the mother bites open the cocoon to allow the escape of the young. Many of the *Thomisidæ* also guard their cocoon, embracing it for long periods at a time, as has been observed in *Thomisus, Olios* and *Xysticus.* Some Theridiids also guard their cocoons and carry them about; there is a very remarkable case of maternal solicitude described by Kathariner for *Stegodyphus lineatus;* and Seidel states that all the Theridiids which carry their cocoons about bite them open to allow the escape of the young. The Attid *Salticus* has also been described as a cocoon-guarder. One Drassid I have found to hold her cocoon and carry it about. *Pholcus* is also a well-known example, holding her cocoon in her jaws, but she does not remain holding it continuously until it hatches, but I have found will hang the cocoon upon the web in order to feed and to clean herself. McCook has given a broad general account of the degrees of maternity among spiders, and I will go into the subject here no further than to state that in most families and species there is no marked maternal solicitude for the cocoons and young. The case of the *Drassidæ*, when the female is generally found near her cocoon, is not a case of maternal solicitude, but the mother remains near the cocoon because she chanced to place it in her narrow domicile; an exception is found in *Drassus neglectus,* described in the preceding pages.

Courtship.—It is difficult to define what has been called "courtship" in animals; a general definition would be: the performance, immediately preceding the copulation, of peculiar motions by the male. But this is hardly an adequate definition, for an eager male always acts differently in the presence of a mature female than he does at other times. We should then have to say "a rhythmically repeated set of motions on the part of the male, continued for some time before copulation."

Using the idea of courtship in this sense, we find a courtship in two families of araneids, each of whom construct no webs, namely, the *Attidæ* and the *Lycosidæ.* The courtship of the *Attidæ* has been described for a considerable number of species by the Peckhams, and these authors have studied it particularly with regard to the relative value of the theories of Sexual Selection expressed by Darwin and Wallace. They find the courtship of the Attids to consist sometimes in dances, sometimes in remarkable posturings, sometimes in a waving of the legs or palpi by the male; and they interpret these motions as in each case an exhibition before the female of bright colors and peculiar structures by the male. The *Attidæ* are the most brilliantly colored of all the spiders, and some of them evince courtship motions to a degree not shown by any others. Menge and Treat have briefly noted courtship motions among *Lycosidæ,* and I have described them in the earlier part of this paper for *Pardosa nigropalpis, Lycosa stonei, L. lepida* and *L. scutulata.* Without repeating the details of the observations, it may be stated that the actions of the male consist in a rhythmical motion of the first pair of legs (waving in the air or tapping upon the ground), sometimes accompanied by waving of the palpi.

I have not found in my own studies, nor do I find in the observations of others, indications of true courtship in any other araneid families. To be sure, in web-makers like the *Pholcidæ, Theridiidæ* and *Epeiridæ,* the males communicate signals to females, and are answered by them, by pulls upon the web-lines connecting the two individuals. And in some *Agalenidæ,* as *Tegenaria derhami,* the males approach the females very slowly at first, tapping upon the horizontal sheet of the web with their palpi and first pair of legs. But such motions on the part of the male should be interpreted rather as signals of the male to determine the sex and the degree of eagerness in his partner, than as a courtship proper. Similar are the approaches of the Dictynids. The male in the *Thomisidæ* (*Xysticus stomachosus*) makes no preliminary motions whatsoever, but as soon as he touches the female seeks to immediately mount upon her back.

The question of the psychology of courtship among animals is a very great one. How, in the first place, does one sex recognize the other as such? One of the greatest wonders in the study of animal habits, though it is so general that its strangeness is overlooked, is that one individual, before it has once experienced an act of union with an individual of the other sex, has the sense that that other individual can gratify its desire, and can unerringly perform that act. In the spider it is still more remarkable, for the male has first to perform the act of charging the palpi with sperm. This is no act of mere automatism; here the animal shows most truly that it cannot be compared with a machine. "Gonotropism" is a mere name and does not explain nor classify the process. Broad questions like this one must be elucidated before we can hope for any adequate explanation of courtship, a performance of secondary importance, and consequently I would call attention here merely to certain peculiarities in the courtship of spiders.

In the first place, courtship is primarily an expression of eagerness upon the part of the male. The male is mature, and the recognition of the opposite sex in a state of maturity also stimulates him to the excess of desire. It may be at first a mental state, which then reflects upon the organization and perturbs the latter. Great excitement finds expression in muscular activity, and hence the peculiar, exaggerated movements corresponding to an abnormal state of stimulation. In some animals the male, once so excited, rushes at the female; in other he does not do so immediately, but goes through a preliminary set of motions, which may be termed courtship when they are regular and more or less rhythmical. Now in the case of the araneids, why does not the male immediately hasten to the female, since by so doing he would most quickly gratify his desire? Several answers might be suggested: (1) that the male seeks to reach the highest pitch of excitement, or waits until that state is reached, before approaching the female—having, as it were, a pleasure in the state of excitement itself; or that (2) he strives first to assure himself of the eagerness of the female; or that (3) he strives first to stimulate the female to equal eagerness. The first of these answers probably accounts for a certain part of the delay before the act of coition, but not for all of it. The second answer, I think, accounts for the remaining part of the delay, while the third answer is hardly admissible, and for the following reason: Deep-rooted in every spider is caution in approaching another individual, particularly upon a foreign web (and in web-making species the male always approaches the female upon her own web). This is well marked in Epeirids; the male approaches and retreats many times tentatively until he assures himself, by the female remaining quiet, that she is not hostile to him. A decided attack by the female, and I have found the male to generally cease his approaches. His peculiar motions during his approach, be they courtship or not, are referable to his excitement. The approach is then marked by a combination of fear and of intense excitement, more or less restrained by this habit of fear. Certain attitudes of the male, in the *Attidæ* particularly, as the Peckhams have demonstrated, are such as to exhibit most clearly before the female sexual beauties or eccentricities of form or color. But the point which I wish to emphasize is, that there is no evidence that the male is conscious of exciting the female thereby; by such motions and attitudes she certainly recognizes him as a male, and perhaps is herself stimulated to a state of sexual desire, but the male does not carry out these performances in order to stimulate her.

In the Lycosids with a decided courtship, a part of the courtship is a straightening out before him of his first pair of legs by the male, and then a withdrawal of them. But this is only an exaggerated performance of motions that he exhibits in other mental states; these legs are his main organs of touch as he walks, and also his main organs of guard; they are used similarly by the female. Each sex, in answer to an act of hostility, elevates these legs and directs them forward. Here is an act of caution, and the male in courtship simply exaggerates the expression of this act. Now in two of our American species, *Lycosa ocreata* and *Lycosa stonei*, the tibiæ of this pair of legs are thickly furred with black hairs, making them very conspicuous. In *Lycosa stonei* the male in his courtship waves these legs so as to show their furring to the female, but waves them in approximately the same manner as do Lycosids which possess no such secondary sexual ornaments. But the male of *L. ocreata* does not wave these legs. Certain Attids, according to the account of the Peckhams, exhibit courtship motions of such a very bizarre nature that they would seem at first sight as not referable to movements shown when the male is not sexually excited; yet some of them may be found to be excessive expressions of some of the latter group of movements.

Thus the motions of the male in courtship are to be directly explained as a muscular expression of his intense eagerness, of vitality in its highest state; though some, at least, of these motions are merely exaggerated repetitions of movements which he performs under other conditions. Such performances probably do stimulate sexual eagerness in the female, by advertising the performer as a male; but there is no evidence that the male consciously performs for that end. It is as a man under the influence of strong drink: smiles are produced by his antics, but he does not consciously occasion the smiles.

The male alone does not make all the approaches, but sometimes the female likewise. Thus in *Lycosa scutulata* the female taps the male with her legs when she is willing for copulation, and the females of the other Lycosids studied by me bend their heads down to the ground as a similar indication. The female of *Theridium tepidariorum* signals very energetically to the male, by repeated pulls upon the web-lines, and appears to be first in the courtship. Other females, as of the *Pholcidæ* and some *Epeiridæ*, give no active expression of readiness, but by remaining perfectly quiet, thereby not showing hostility, assure the males of their willingness. The only case I know of when the male seizes the female by storm is *Tegenaria derhami*. Since the male ceases his courtship as soon as the female gives the signal of desire on her part, very plainly a portion of the delay before the copulation is due to the male testing the eagerness of the female.

Sexual selection may well be, in some cases, the process which has occasioned secondary sexual differences, and in the case of the spiders the view of the Peckhams in this matter is probably correct. That is to say, the differences in the males are due, not to "greater vitality" of the male sex, but to selection by the females. Yet I would make the point that there is no evidence that the females are influenced by any æsthetic sense of the beautiful in males—that the females do not select males that seem most beautiful to them; but that they select those males which, by peculiarities in movements, color or form, most quickly and certainly announce their sex. Other things being equal, the male that is most eager would be most active in his courtship motions, and would stand the chance of being selected by the expectant female, since he would be advertising his sex most prominently;

and not because he would appeal to her as more beautiful or graceful than other males.

These views as to the origin and meaning of courtship in spiders may be briefly summarized as follows: The mature male is stimulated to great excitement by a perception, visual and tactual, of a mature virgin female, and this excitement finds its expression in muscular movements. The male does not immediately embrace the female, for in most spiders he is the weaker individual, but delays in order to first determine whether the female is eager or hostile. Rhythmically repeated motions of the male during this period of delay constitute courtship, and these motions are for the most part exaggerations of ordinary motions of fear and timidity. By such motions he advertises himself to the female as a male, but there is no proof that he consciously seeks to arouse her eagerness by æsthetic display. That male is accepted by the female who most quickly and surely announces himself, by his rhythmic movements, to be a male; and there seems to be no good reason to hold that the female is actuated in her choice by sensations of beauty. If such a process be interpreted as sexual selection, it would be a selection of the male who most determinedly announces himself to be a male, and not as the male who appeals to the female as the most beautiful.

Post-nuptial moult.—It is generally believed that in araneids the final moult precedes the mating. But Bertkau (1885) has shown that in *Atypus piceus* a moult, with change of the seminal receptacles, occurs after the first year of oviposition; and I have described here for *Lycosa ocreata pulchra* a moult following a successful copulation. Accordingly, in some cases a moult may follow the mating; and probably this will be found to be general in species that live several years, since increase in body size occasioned by rich feeding would appear to necessarily induce further moults.

Wagner (1888) has described the histological changes of moult. I would simply add here that the moult in all the spiders observed by me follows the same plan: a horizontal split of the old skin along the sides of the abdomen and of the cephalothorax (here just above the legs and the jaws), so that the skin breaks into a dorsal and ventral piece. This is quite different from the process of moult in insects and crustaceans.

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Explanation of Plates IV and V.

All the drawings are freehand outline sketches, and as such do not claim to be accurate in all dimensional proportions, though the attitudes are true to nature and all are studies from life. The degree of magnification varies in the different figures.

Plate IV, Fig. 1.—Lateral view of a female *Ocyale undata*, hanging in her web and holding her cocoon.

Fig. 2.—Copulation of *Theridium tepidariorum*, lateral view at the instant when the male seizes the female.

Fig. 3.—Copulation of *Pholcus phalangioides*, only the proximal portions of the legs shown.

Fig. 4.—Copulation of *Agalena nœvia*, the female below and partially upon her side, the male's left palpus applied to the epigynum.

Fig. 5.—Copulation of *Acrosoma gracile*, the male with his left palpus applied to the epigynum; the male is drawn proportionately somewhat too large.

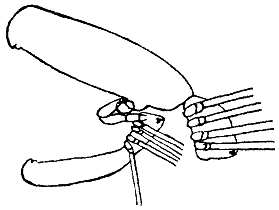
Plate V, Fig. 6.—Copulation of *Dictyna volupis*, the left palpus of the male inserted; the third leg of the male and the posterior end of the abdomen of the female are supported by the web.

Fig. 7.—Copulation of *Xysticus stomachosus*.

Fig. 8.—Copulation of *Pardosa nigropalpis*, lateral view, the male with his left palpus inserted.

Fig. 9.—A female *Pardosa nigropalpis* holding her cocoon beneath her cephalothorax; this is the attitude when she finishes spinning the cover of the cocoon, and when she bites it open to free the young.

Fig. 10.—Copulation of *Lycosa stonei*, dorsal view, the male inserting his right palpus, the cephalothorax of the female hidden by the male.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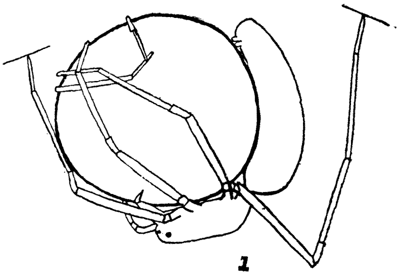
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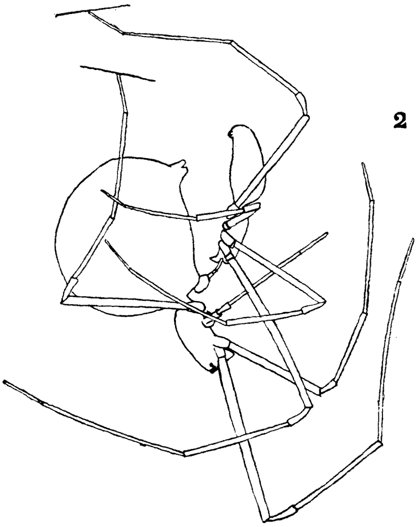
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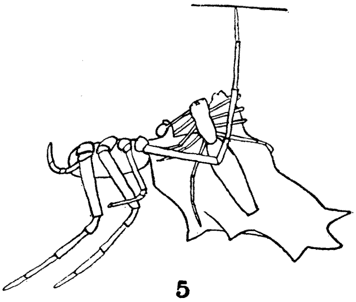
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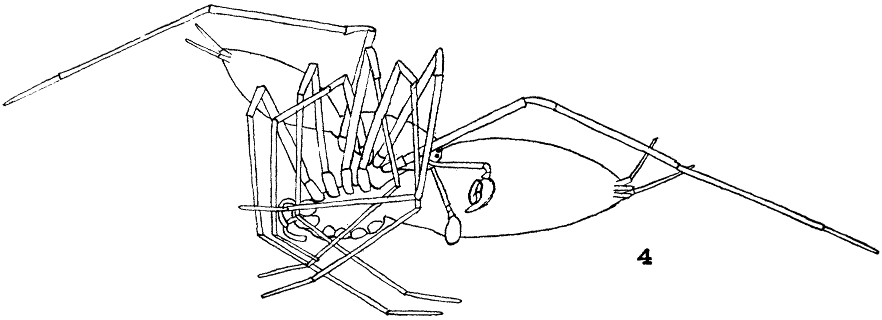
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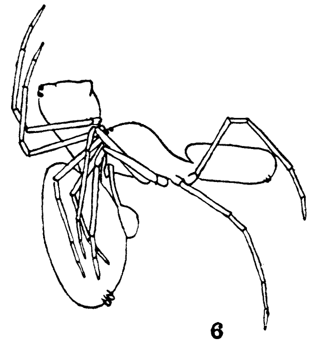
MONTGOMERY ON HABITS OF SPIDERS.



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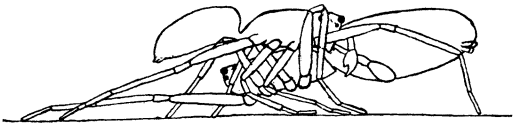

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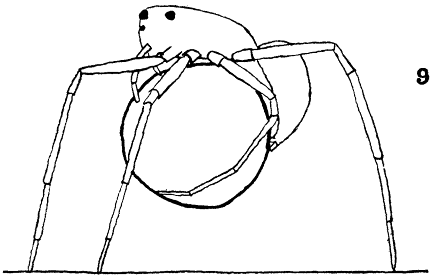

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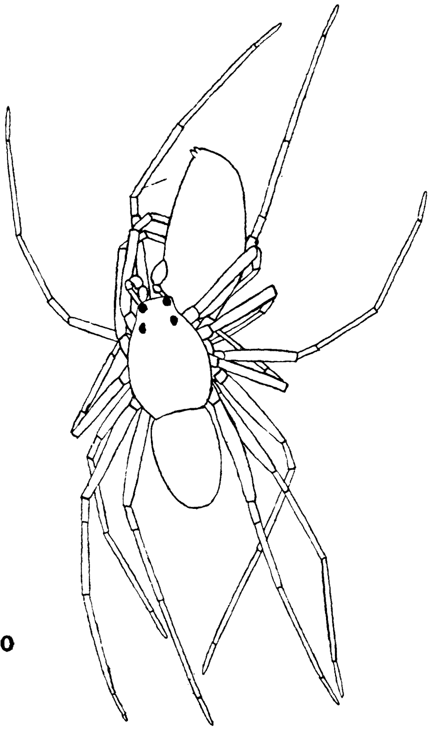

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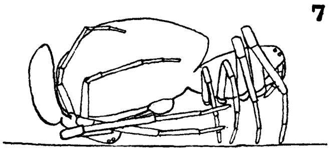

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